

Evaluating Cultural Learning in Virtual Environments

Erik Malcolm Champion

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**Department of Geomatics, Faculty of Engineering
And the Faculty of Architecture, Building and Planning
The University of Melbourne**

Abstract

There is still a great deal of opportunity for research on contextual interactive immersion in virtual heritage environments. The general failure of virtual environment technology to create engaging and educational experiences may be attributable not just to deficiencies in technology or in visual fidelity, but also to a lack of contextual and performative-based interaction, such as that found in games. This thesis will suggest improvements will result from more research on the below issues:

1. Place versus Cyberspace: What creates a sensation of place (as a cultural site) in a virtual environment in contradistinction to a sensation of a virtual environment as a collection of objects and spaces?
2. Cultural Presence versus Social Presence and Presence: Which factors help immerse people spatially and thematically into a cultural learning experience?
3. Realism versus Interpretation: Does an attempt to perfect fidelity to sources and to realism improve or hinder the cultural learning experience?
4. Education versus Entertainment: Does an attempt to make the experience engaging improve or hinder the cultural learning experience?

This doctoral thesis outlines a theoretical definition of place, culture, and presence that may become a matrix for virtual environment design as well as a discussion of the advantages and disadvantages of appropriating game-style interaction to enhance engagement. A virtual environment was built using Adobe Atmosphere to test whether cultural understanding and engagement can be linked to the type of interaction offered.

The thesis also includes a survey of evaluation mechanisms that may be specifically suitable for virtual heritage environments. In its review of appropriate methodology, the thesis suggests new terms and criteria to assess the contextual appropriateness of various evaluation methods, and provides seven schematic examples of game-style plot devices that lend themselves to evaluation.

The test-bed is the evaluation of a virtual archaeology project in Palenqué Mexico using theories of cultural immersion as well as computer game technology and techniques. The case study of Palenqué involved five types of evaluation specifically chosen to assess cultural awareness and understanding gained from different forms of interaction in a virtual heritage environment.

Declaration

This is to certify that

- (i) The thesis comprises only my original work towards the PhD except where indicated in the Preface.
- (ii) Due acknowledgement has been made in the text to all other material used.
- (iii) The thesis is less than 100,000 words in length, exclusive of tables, maps, bibliographies and appendices.

Erik Champion

Brisbane, January 2006.

Preface

This writing is the work of the author, where others have contributed they have been acknowledged in the Acknowledgements and in the relevant papers listed in the Appendices.

As part of the doctoral candidature two postgraduate papers were enrolled in and passed. They were:

2001: Interaction Design and Usability

2002: Statistics for Research Workers

The work resulting from this research that is available in published (printed and online) form is listed in the Appendices.

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"The Big Print Giveth and the Small Print Taketh Away"- *Step Right Up* by
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I apologise in advance for any omissions, mistakes, or other small print issues.

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1.1 Walking the Walk: Virtual Travel

Why develop virtual environments?

An increasing amount of literature suggests that Virtual Environments have been successfully developed for simulation, entertainment, medicine and education. There are distance learning and virtual training environments for sports too (Booth, 2003, para. 7; Times Wires, 2003).

...an electronic coaching system based on Hawk-Eye technology has been installed in the indoor nets at England's new national academy at Loughborough. To perfect their technique, young players will be able to see instant replays of their batting and bowling performances....Michael Atherton, former England captain and opening batsman approves of this latest technological innovation.

"You try to construct your innings in your head before you play, and if virtual reality goggles could help you to do that, then all well and good."

Military training is taking similar strides (Warren, 2003), and Virtual Environment technology (or Virtual Reality or VR as it is popularly known), is being developed for phobia treatment, (Robillard et al, 2003). Jacobson (2003, para. 5) noted its ability to augment medical treatment and social work:

Other researchers are making progress in alleviating pain during burn recovery and chemotherapy by distracting patients with realistic VR scenarios. And scientists in the United States, Europe and Israel have joined forces to use VR to teach the elderly how to get around, perform daily tasks and navigate public spaces--efficiently, and without getting hurt.

Researchers of presence in virtual environments and websites advocating virtual medicine suggest that digitally mediated environments mentally, emotionally, and physically affect us (Virtual Reality Medical Center, 2003; <http://www.Presence-research.org>, 2003). Hospitals have adopted VR techniques for pain management (Lockridge, 1999), and according to Heard (2003), Virtual Reality is used to help people enter calm meditative states while sitting together in large public spaces.

Marsh and Wright (2001) defined four general types of Virtual Reality environments (VR): work-related; informative; entertainment; education and training.

Extrapolating from their classification system, we could thus argue that virtual

environments may be useful for the following reasons:

Virtual environments can help:

- Promote technology for the sake of technology (product showcases). You can see such various examples on the websites of Shout3d, Pulse3d, Wild Tangent, Blaxxun, MindAxel, etc.
- Enhance motor-coordination and related physical skill, especially in games. Some of the best examples of Macromedia's Director Studio 8.5 are the three-dimensional shooter games.
- Synergise learning by the use of various multimedia, for example, 3D software has been used to create models of the human heart in action, as well as show how to service a car's engine.
- Preserve cultural artefacts, through a three or even four-dimensional record of history. For example, UNESCO's World Heritage Site and the Virtual Heritage Society's site.
- Present ideas objects or techniques difficult to perceive or conceive of in real-world form, or in conventional media. This can range from Japanese construction details to electric waves transmitted through the human brain or even the formation of stars.
- Extend the perceptual experience or perceptual boundaries of observers. Various environmental art 'happenings' have been around for decades. A multimedia cinema was proposed as early as the 1950s. Collaboration between sound composers and virtual reality designers is burgeoning; one of the fundamental criterions for acoustics is spatial presence.
- Engender social discussion. Multi-user chat worlds include, Activeworlds, Outerworlds, Vnet, Cybertown, Blaxxun communities, iCity, Galaxy Worlds et al.

Hence, if successful examples exist, why continue to research at a conceptual level rather than gradually improve on successful existing case studies?

One potentially profitable and useful purpose overlooked is also the one that appears to be catered for as a rudimentary requirement of virtual environments. That is, virtual travel. The reason why we travel in the real world is not necessarily addressed by current design strategies for virtual environments. If this supposition is correct, then some of the fundamental concepts that virtual environments are founded on, need critical inspection.

1.1.1 Living in Reality Requires More Than a Compass

There are many research papers on the issues of virtual navigation, orientation,

and wayfinding. Orientation and wayfinding are important functional elements of travel information, but they are not the only important components of travel experience.

Some academics have already suggested that navigation is more than wayfinding. Beynon (1998, p. 706) wrote:

In direct opposition to 'The Image of the City', 'The City and the Sign' (Gottodiener and Lagopoulos, 1986) presents a number of views from urban semioticians that highlight the limitations of the Lynchian and cognitive perspective. The crucial thing missing from the traditional geographies is the failure to appreciate how environments are *conceived* by people as opposed to simply *perceived* by people.

To enrich and encourage our understanding of a certain place, we need to gain a conceptual understanding of what makes it significant and unique, and which elements (people, activities, events, and objects), make it a distinctive place. Only if the tourist market is intrigued by the prospect of travelling through, in, and to a place (as part of the 'travel experience'), is it then likely to be interested in 'travel information'. In other words, if we contextualise the travel experience via digital media, people may better understand the unique and significant aspects of that place as perceived by the inhabitants (Modjeska, 1997).

1.1.2 Moving Past the Picture Frame

Photo-realism may allow us to picture what a place currently looks like or looked like, but it does not give us the 'full picture' on the process of living in that place, and the perceptions that inhabitants of that place have developed. Gillings wrote (2002, p. 17):

[The] archaeological use of VR is at present all about the creation of pictures....Only after they have been generated does attention turn to the uses to which such models can be put.

There are also many websites purporting to offer virtual travel or virtual tourism. However, what they offer are generally static or moving pictures of foreign places, set music clips, information on timetables and prices, or at most, 360 degree panoramic images that are interactive insofar as you can spin the camera around, and zoom in and out of the panorama.

Two-dimensional images and three-dimensional panoramic images available through the Internet may allow us to identify objects, but they are not likely to help us experience inhabiting that place, moving through that place, or understanding the dynamic and ever-changing relationship of people and place.

Digital technology can integrate the real and the conjectural, as well as

synchronous and asynchronous data, into conceptual user-specific information. This capability suggests that virtual environments may augment real-world travel and tourism experiences, rather than merely emulate them.

1.1.3 Being Not-there May Be More Achievable

“...simulations are wonderful resources for taking us to a time or place that we are unable or unlikely to experience directly.” (Jane Boston, General Manager, Lucas Learning Ltd., quoted in Aldrich, 2004, p. 37).

Virtual travel may not be like ‘being there’; it may offer more, ‘being Not-there’. That is, it provides us with a portal into what could have been, not what still is. In this interpretative sense, it may in fact be even more educational, as it can rely on asynchronous multimodal data.

Sometimes we wish to understand people who live far away or in distant times that are not easily accessible to us. Multimedia and virtual environments as subsets of digitally mediated learning are great for conceptual understanding, “dealing with time and scale”, or harmful or serious situations (Aldrich, 2004, p. 37).

Many ruins are bereft of their artefacts, which sit forlornly in the museums of past colonial powers. In that respect, Internet media may prove more immersive, useful and educational than actually standing at site where history once took place.

The ethical issue of the ‘digital divide’ may obscure another social phenomenon, that of the housebound who rely on their computers for news of the outside world. Virtual travel is not just useful for promoting future travel; it may negate the cost and fear of travelling. Virtual travel can help reach and educate the growing potential market of people who for whatever reason cannot leave the house.

1.1.4 Being Not-there May Safeguard the Place

Some tourist sites are so popular that the sheer number of the tourists themselves ironically threatens the travel experience. (Freemantle (2000, para. 2) wrote:

No wonder the city attracts visitors by the millions each year....Venice both thrives on and suffocates from tourism....The city attracts numerous tourists, but it is becoming less attractive as a place to live for the local population or as a place for businesses to set up offices.

Tourism can destroy the local industry, and erode local culture. Businesses that have served the local populace for generations may have to move out of town because they are not believably ‘authentic’ or suitably ‘historic’ enough to be included in packaged tours. Tourism can even transform the urban fabric: the inner city may become crowded in summer and desolate in winter. ‘Experiences’ and ‘artefacts’ can be introduced that are actually not local at all; they just appear to

be, and are easily placed in shopping bags and placed on mantelpieces. For example, Grabmeier (2004, para. 3) decried the effect of mass tourism on Venice.

It's no wonder that tourism may be killing Venice. "Every year Venice becomes more like an amusement park and less livable for Venetians," Davis said. "Of course it still exists as a city. But as a distinct culture, as a society, I can't say that Venice still functions anymore."... Most of the original Venetian culture has been swept aside, replaced by a tourist "monoculture," dedicated almost entirely to serving the 13 to 14 million outsiders who descend each year on this city of only about 65,000 permanent residents....Now, Davis said, gondolas are strictly for tourists, and they aren't even a means of transportation -- they run pre-set routes that give a gondola "experience" without going anywhere...."Yet the tourists mostly don't seem to mind the crowds," Davis noted. "They largely accept the city as a giant strip mall and are happy to find all the tourist trinkets available to buy on every side, even though most of this 'touristware' was actually made elsewhere.

Real travel also creates a market for mass consumption, non-degradable consumer products, and resource-intensive transport that damages the environment.

Holzman (1997, para. 20) wrote:

In 1993, aircraft emitted 350 million pounds of VOCs [volatile organic compounds] and NO_x [nitrogen oxides] during landing and takeoff cycles, more than double 1970 levels, according to the NRDC report. These two classes of compounds are precursors of ground-level ozone, which can interfere with lung function. "During the summer...between 10% and 20% of all East Coast hospital admissions for respiratory problems may be ozone-related," says the NRDC report...

Airports are among the greatest sources of local air pollution. A major airport's idling and taxiing planes can emit hundreds of tons of VOCs and NO_x annually. John F. Kennedy International Airport is the second largest source of VOCs in New York City. LaGuardia is among the major sources of NO_x. The growth of air traffic further frustrates mitigation of environmental problems. Air traffic is expected to double nationally by the year 2017 and internationally by 2010, according to the Federal Aviation Administration (FAA). At least 32 of the 50 busiest U.S. airports have plans to expand operations

The flash of a camera will not damage a priceless artefact when simulated on a computer screen. Virtual travel can potentially help lessen the impact of tourist erosion. Many heritage sites are now being overrun; the Lonely Planet guide on South America actually suggests that tourists do not visit Machu Picchu. In the future, we may need digital media to help save our cultural heritage from ourselves.

1.1.5 Share By Being Not-there

Virtual environments can also act as collaborative virtual environments (CVEs). They may not just be experienced with others, they may also act as travel-diaries, the environment itself may be able to record our journeys, favourite views or spots, and either remind us of them later, allow us to transfer the 'highlights' to more portable appliances, or communicate our 'travels' to friends and family on the other side of the planet.

1.1.6 Evaluation without Questionnaires

The more sophisticated computer games of today can evaluate user performance and change the difficulty of the tasks to suit. Some software and web browser additions also track user viewing patterns and preferences in order to improve the product. Via such devices, we may be able to gain useful feedback on the user travel experience without interrupting it, and without resource-intensive questionnaires or intrusive market surveys.

1.1.7 The Implications for Virtual Travel

We might argue that virtual environments and real-world travel share some very interesting mutual issues. In augmenting real-world travel, successful virtual travel and heritage environments should attempt to provide some or all of the following capabilities. According to Mosaker (2001), Gillings (2002), Roussou and Drettakis (2003), and Pletinckx (2003), it should provide the ability to travel across time and space in a way not possible in current reality in order to view what used to be there as opposed to what remains.

Virtual travel has the potential to provide an 'immersive' place-experience, the full and dramatic range of climate and topography (that is, experiences not usually accessible to short-term visitors). There are also opportunities to experience at first-hand important historical events; which requires the meaningful integration of artefacts people and place.

However, people do not want virtual environments to bombard them with too much information. There needs to be filtered relevance, ways that users can customise and filter the information.

With travel, there is the problem of portability. Users want to be able to have the means of recording a travel experience and carrying it (along with travel information).

Finally, the experience needs to have some potential aspect of social interaction; people usually find it more meaningful to be able to share their experiences with

others. Many travellers want to have pre-visit experience of a destination, as in knowing something about the place before they spend money and time visiting a place that they do not enjoy. If they do enjoy that destination, they want to be able to record or have a memento of that experience. We might even surmise that if on reaching the destination, the user achieved a goal contextually relevant to the local culture, that would add to the sense of engagement.

1.1.8 Learning via Virtual Travel

A question frequently asked is “Does the learning experience in a virtual environment offer any advantages over and above conventional learning experiences”? Even since the early days of VR people have made suggestions that a virtual environment will facilitate the learning process by allowing people to experience environments that are otherwise unavailable to them. This could include situations that are precluded because of safety, time or distance factors.

As well as being able to represent environments that are based in conventional physics it is possible for the user to experience abstract environments. Therefore, it seems sensible to assume that virtual environments will be able to facilitate a range of different experiential learning inquiry. Of course, other learning technologies are able to support these different experiences. However, the flexibility of the VR system should make it easier to host different learning experiences on the one platform. (Franklin, 2000, p. 122).

From the above quote, we can see that virtual environments may prove useful to travel in several ways. One in particular is through providing travel experience rather than just travel information. As virtual environment technology is potentially additive, multimodal, interactive, and open to real time augmentation, it lends itself to both social and cultural learning as vicariously explored through doing rather than imaginatively reconstructed (as in book reading) or experientially followed (as in linear media like films).

The real world has many constraints that prevent us from learning about objects in the real world. For example, we are not allowed to step on Stonehenge boulders even though they are in danger of being uprooted by badgers (Jones, 2004). However, digital media allows one to try out ideas and test hypotheses in order to learn, without destroying the actual thing that one is trying to understand.

This ability of digital media to afford learning was the starting motivation for this thesis, cultural learning experiences available via virtual travel environments. It particularly attempts to isolate and evaluate the more effective and preferable types of interactivity and interactive elements available to three-dimensional virtual heritage environments.

The chosen site is the Classical Mayan city of Lakam-Ha in Palenqué Mexico, and

the great majority of the artefacts of that city of inscriptions are simply no longer there. However, the Internet can bring the landscape, the buildings, the artefacts, reasonably accurate reconstructions of the native music, representative animated avatars of the people, and past historical and environmental conditions all together in one multimodal interactive gestalt. In addition, it is deliverable over the Internet.

1.2 Research Objective

In 1997, Jane Murray published *Hamlet on the holodeck: the future of narrative in cyberspace*, which forecast the computer as a future platform for interactive drama. Yet a great deal of recent literature has focused on the failure rather than on the success of virtual environments (particularly three-dimensional ones), as an engaging medium of entertainment and education.

Many critics have argued that virtual environments have yet to overcome a large number of impediments to their widespread dissemination, distribution, and use. Two fundamental restrictions are a lack of engagement and a lack of presence (as in, a feeling of “being there,” of being transported to an actual place).

Virtual environments are often criticised for evoking ‘cyberspace’ but not ‘place’. In other words, they lack the richness of the associations and encounters that occur in real space (Benedikt, 1991; Johnson, 1997; and Coyne, 1999a). Even though place seems to be a central issue, how it can be clearly defined and demarcated, and its relation to presence and specifically to cultural presence is seldom discussed (Champion, 2003b). We have seen that there is scope for developing suitable context for virtual travel environments but the critical literature is so far descriptive rather than prescriptive. That is, it describes what is wrong or missing with virtual environments, but not how to test possible design solutions. The research objective is thus to clarify and evaluate key factors that may improve the usability and user satisfaction of virtual travel environments for both education and engagement.

1.3 Hypothesis

This thesis argues that issues with currently available virtual environment technology affect a sense of engagement in virtual heritage projects. It will be argued that certain criticisms of the technology and use of virtual environments have been indirectly addressed by entertainment software design. It is also argued that while virtual environments can be used to simulate historically situated cultural perspectives, the above criticisms first need to be solved.

A proposed solution is to apply the interactive mechanisms used in games to virtual

heritage environments. It is hypothesized that:

- o Modifying game-style interaction to suit the virtual reconstruction of a cultural site will allow for a more culturally immersive learning environment.
- o Further, it may be possible that interactive mechanisms can be used for evaluation of user engagement without simultaneously interrupting the user's feeling of engagement.

1.4 Four Major Problems

The above raises serious problems in designing virtual environments that in some way depict the values of past cultures. I wish to summarise these issues in the form of four major questions.

1. Place versus Cyberspace: What creates a sensation of place (as a cultural site) in a virtual environment in contradistinction to a sensation of a virtual environment as a collection of objects and spaces?
2. Cultural Presence versus Social Presence and Presence: Which factors help immerse people spatially and thematically into a cultural learning experience?
3. Realism versus Interpretation: Does an attempt to perfect fidelity to sources and to realism improve or hinder the cultural learning experience?
4. Education versus Entertainment: Does an attempt to make the experience engaging improve or hinder the cultural learning experience?

The first problem is what elements of a cultural place are missing from virtual environments. Merely creating a reconstruction of a cultural site does not mean that one is creating a platform for understanding and transmitting locally specific cultural knowledge. We need to understand what distinguishes a cultural site from another site; we need to understand the features of place as a site of cultural learning.

The second problem is how to create an appropriate feeling of immersion or of presence in a virtual environment; how we make the past come alive for people so that they feel they are transported 'there'. This has often been seen as a technical constraint to the rendering of realistic virtual scenes (due to the speed of the Internet or network connection, limited processing power or the computer's capacity to render a large number of objects on the screen in real-time). This thesis, by contrast, suggests designers foster engagement not only through realism, but also through contextually appropriate interaction.

Culture understood from the distance of a hotel or guidebook is obviously not the same as the dominant culture that guides, constrains, and nourishes a local inhabitant. In addition, a virtual traveller is not the same as a virtual tourist. Despite or perhaps because they have a goal to solve, and have more constraints and more direct immersion in the local way of doing things, people who travel rather than tour arguably have richer and more interesting experiences.

The tourist leaves home and brings in their luggage images and concepts about what and who they will meet; in this way the tourist 'has already lived' the contact with the inhabitants and their local culture...tourism creates [a sense of] **invulnerability**. (Cipolla, 2004, n.p., her emphasis).

Tourists may want to share cultural perceptions and learn through doing, being told, observing, and asking. Yet in a real world environment, the industry may act as a cocoon. Real world tourism can lead to non-interaction, to being hermetically sealed in a sterile 'they lived like this' environment. Contextual engagement in the activity is missing, there is no locally related pressure, or necessity to understand the 'embedded' meaning of local cultural activity based on artefact. In order to be framed as an 'experience', local culture becomes high culture, non-invasive, and thus not so immersive.

In a virtual travel environment, you may want to be able to travel through time and space, to explore, and to interact with people, objects, and local goals, to explore thematically as well as spatially. Cipolla (2004, n.p., her emphasis) would see this as travel as opposed to tourism: "The **relation** can begin when a traveller, without preconceptions or prefigured images, encounters a community, a monument, a natural environment or a cultural expression...'

In a virtual environment, the setting should also be an interactive artefact. You should be able to interact with the environment as much as a local, to leave a trace, but also to communicate with the local inhabitants, and be able to understand or at least recognise their locally situated perspective.

Thirdly, our idea of what reality is may be at odds with understanding the past or a distant place from a local perspective. What does reality mean when we are trying to recreate and understand cultural perspectives? To what extent should we try to adhere to our normal concepts of reality?

In a virtual heritage environment, the more one can master local cultural behaviour, the more one can understand significant events from the local cultural perspective. Mastery of dialogue and artefactual use, as viewed from a local cultural perspective, may lead to enhanced cultural immersion. It may consequently lead to a heightened sense of engagement.

Yet it is possible that attempting to create contextual affordances and constraints will create too heavy a cognitive load on the virtual traveller, or require a high degree of skill and a large amount of time immersed in a virtual environment. Is it useful, desirable, or even possible to interact with digital reconstructions of different cultures in a meaningful way? Could interaction actually interfere with the learning process?

Fourthly, if we do manage to create an engaging and believable virtual environment, will the novelty or entertainment value actually interfere with the cultural understanding gained by the users? In virtual heritage environments, this is particularly evident in the conflict between individual freedom to explore and the more pragmatic need to convey historical information. For example, we may create an entertaining game. However entertaining that game may be, will it allow us to convey varying levels of historical accuracy in reconstructing the past?

1.5 Significance

One may well argue that such virtual representations cannot compete with actually visiting the site, but the point is whether such projects have a valid purpose and fit an important need; not whether they mirror reality. In fact, if we wish to understand how such ancient people as the Mayans of Lakam-Ha at Palenqué thought, believed, and acted, we need a non-realistic world to understand them and their beliefs. They saw, imagined, and related to things in a way a Westerner will not understand by merely travelling to the current remains of their past abode.

A sense of being engaged with different local cultural perspectives is not always possible as a real-time tourist. Digitally mediated technology can attempt to reproduce existing data (archaeological impressions, extant ruins, the original condition of found artefacts, even typical weather patterns), but they can also make more or less accessible and more or less contextual (i.e., augment, filter, constrain or optimise) the user-experience.

There is a shortage of research integrating theory and practice on how best to augment or invoke the user-experience of place via digital media (Gillings, 2002, p. 17). By concentrating on achieving photo-realism rather than on understanding the unique capabilities for digital media to enrich the user-experience, there are significant questions still to be answered.

For example, we currently have little evidence as to whether virtual travel environments can afford useful and unique ways for augmenting and evoking awareness and understanding of distant places and foreign cultures. Critical

research needs to be undertaken on the specific abilities of digital media to aid engagement, understanding, and awareness of other cultures.

One possible solution is to study why computer games are so popular, and whether their interactive elements can be applied successfully to interactive learning environments. Games have the ability to synthesise narrative, conjecture, computer-generated objects, contextually constrained goals, real-time dynamic data, and user-based feedback (Mateas and Stern, 2001). It is possible that through this interactive richness, rather than through a high-tech ability to reproduce elements of the real world, that people can both learn and enjoy alterity (experience of the 'other').

The intended audience that could most benefit from the theoretical part of this research are those who either communicate historical perceptions via digital media, or those who wish for more prescriptive (rather than descriptive) notions of 'place' and 'cultural presence'. The case study may further interest those designers interested in improving engagement via interactive elements. Finally, I hope to go some way in developing methods for addressing the user needs of potential virtual travellers and virtual tourists, especially when they wish to gain an atmosphere of a place before travelling there or are interested in a culture not easily accessed by conventional means.

1.6 Précis

The central question of this thesis is thus:

How can we increase awareness and understanding of other cultures using interactive online digital visualisations of past civilisations?

In order to answer the above question, this thesis first questions the success of current virtual environments, and asks whether they are capable of producing a platform that supports the experience and understanding of place-inscribed culture. To answer this question, a typology of successful virtual environment applications is suggested. These include online communities, travel VR websites, game engines, VR used for training, and VR used as part of therapeutic means to either relax or divert patients, or to cure phobias.

The thesis suggests that impeding the success of virtual environments in terms of technological constraints, lack of evaluation techniques and results, and a lack of content-specific applications that best utilise desktop computing capabilities, and respond to user needs. It suggests that much more work needs to be done on not just usable but also useful content. Specifically, there is a large gap in knowledge

on what might constitute useful and appropriate virtual travel environments, and how contextual interaction may affect our cultural understanding in these environments.

In order to address these issues this thesis is thematically divided into four main sections. Chapters 2-5 focus on four key issues in virtual environments. Chapters 6-8 focus on proposed conceptual advances and ways of evaluating them. Chapters 9-10 describe the selection, creation and evaluation of the experimental design components, and the analysis of the results. Chapter 11 is the concluding chapter.

Chapter 3 deals with the first key issue. This chapter outlines limitations of the 'cyberspace' theorists' notions of place and suggests how these limitations adversely affect virtual heritage environments. A fivefold description of different features of place that may be appropriate for virtual environments is proposed. These five features of place are summarised as

- Uniqueness of atmosphere, selection of artefacts et cetera.
- Some places in nature have the ability to shock or overawe the spectator.
- Memorable places have the power of evoking memories and associations.
- Some places act as either stage or framework on which communal and individual activity can 'take place'.
- Communal places have the ability to identify and reflect individual participants.

Combining literature and various creative arts suggest various components that help create the above place-experiences. Embodiment and dynamic attenuating environmental features as well as phobic triggers; social embedding and cultural agency; place as an inscribable artefact; and causal feedback are all suggested. I note here that there is a danger in automatically simulating all of the above elements digitally.

From the point of view of the designer, a roadmap for designing for three distinct audiences and intentions is instead suggested (Table 2). The three types of environments are categorised as visualisation-based, activity affording, or hermeneutically enriched. The last type of virtual environment is a new addition to the literature of place and cyberspace, and will be focused on, for the importance of place as a cultural site is a central concern in this thesis. For virtual heritage environments in particular, we need to have a clear and distinct idea of what place as a cultural site and the related sense of 'cultural presence' entails.

Unfortunately, the academic communities that respectively research virtual heritage and virtual presence do not often converge. One group has tended to ignore the individual differences and experiential requirements of participants, and the other

has tended to conflate culture with society. Chapter 4 highlights problems in the research community's definitions of presence, and specifically distinguish cultural presence from social presence. Although the distinction may initially sound academic, this chapter argues that it is of great importance to participants' cultural learning, and that it affects the perceived authenticity of their virtual environment experience.

Having suggested that the specific cultural aspects of virtual environments requires more careful attention from the academic community, chapter 5, concentrates on the usefulness and danger of adherence to photo-realism. The chapter is not an outright attack on realism, but an attempt to show where attempts at realism may obscure other important issues, especially in education.

Creating a descriptive and to some degree prescriptive taxonomy of place is only the first step. The next step is to work out the type and extent of interactivity required to make virtual environments both more engaging and more educational. Chapter 6 discusses related issues in using game techniques for virtual environments.

It has so far been argued that virtual environments that afford cultural learning are the least discussed. Chapter 7 suggests possible solutions for enhancing cultural presence in virtual environments, and selects virtual heritage environments as the case study.

This leads into the *Suitable Research Areas* subsection, where the intent and scope of the research enquiry is focused. The purpose of this research is to see if we can identify these interactive elements, in relation to audience purpose, and domain knowledge. The issue discussed is how contextual interaction may affect 'cultural presence' in virtual environments.

Chapter 8 outlines various ways one might be able to evaluate cultural understanding and cultural presence in virtual environments. The chapter is a comparative study of potential evaluation methods rather than a chapter describing a single method to be used. It also describes the criteria to select the test site, the technology, and the evaluation method.

Chapter 9 details how the experiment was constructed in order to answer the research question. It outlines a custom Presence Questionnaire to survey 'cultural presence' in relation to interaction. It develops context to help measure task performance, user preference (through ranking against presence criteria), knowledge recall, subjective experience of time (via frame-rate), and observation recall. It also describes the three groups that make up the evaluation test audience. Chapter 10 reports the data resulting from the evaluation, discusses the results of

the pilot study, and the two main test groups. It details the results from the five types of evaluations, notes various issues and observations that arose from the evaluation, and suggest that the results indicate game-style interaction while increasing engagement may impede cultural learning. The findings may be of particular interest to researchers involved in virtual heritage and cultural tourism. The chapter also presents lessons learnt from applying various evaluation methods, the complex issues of experimental design, and some of the limitations exposed by the modelling approach adopted will be discussed here.

Chapter 11 relates the findings back to the method chosen, the original theoretical underpinnings of the thesis and the hypotheses and questions raised above. The final section includes a novel virtual environment prototype using inbuilt evaluation mechanisms to gauge the effect of various forms of interactivity on user engagement.

References are listed at the end of the thesis, in the *Appendices*. They also include a list of conference papers resulting from this research, and a glossary.

Having suggested that virtual environments may prove a useful perhaps even unique tool for travel information and travel experience, one may then wonder if they have done so, and if not, why not.

2.1 Technological Limitations

Virtual environments are generally assessed in terms of technological development (the amount or sophistication of data geometry or interaction that they can generate or deliver), or in approximation to reality (how realistic they seem).

Technological advances (technology for technology's sake), all too often drive the development and deployment of virtual environments. In the design of digital three-dimensional environments, the pursuit for exact duplication of visual form is all-important, as technological advances rather than content seem to be the main motivating factor of many web-enabled environments.

Technical issues include slowness, and a lack of realism. Other criticisms of virtual environments have pointed to a lack of meaningful content, confusing interface design, orientation and navigation difficulties, and a paucity of useful feedback mechanisms (Costalli et al, 2001; Campbell, 1997).

To some extent, this may have been encouraged by limitations of early software, but even though both hardware and software are increasing in power and flexibility, new and more effective means of interaction are yet to appear. We could further argue that interaction is either limited or not appropriate to its context (Turner et al, 2005, Mosaker, 2001). For example, Schroeder (1996, pp. 114-117) wrote:

Interaction with virtual worlds mainly consists of changing the appearance of objects....there is little difference in terms of content between VR games and existing computer-based games.

2.2 Lack of Widely Distributed Technology

Part of the problem may be to do with the cost of dedicated virtual environment technology, such as the building and maintaining of CAVEs, which stands for Cave Automatic Virtual Environment (Cruz-Neira, Sandin, and DeFanti, 1993). In recent

times, creating virtual environments typically required an army of programmers, a large space for front or rear projection, and computers far beyond the purchasing power of the typical home hobbyist.

Although online environments and 3D chat rooms have appeared in the last decade, the user is typically restricted to certain types of online browsers, operating systems, platforms, and graphic cards. On the other hand, where open platform applications exist or have existed (such as Metastream, Blender3D, Blaxxun, and Crystal Space), we cannot rely on them being around. Web-based 3D technology companies in particular seem to appear and disappear at a rapid pace.

2.2.1 Virtual Environments: Too Large and Too Slow

Virtual environments (VEs), and Collaborative Virtual Environments (CVEs), are too large in terms of file size or finding areas of interest when inside the environment. They contain too much data for many people to download, and walk through, especially on home computers, or on the computers that schools can afford to both buy and maintain. For example, Moshell and Hughes (1999, section 7) argued the following:

For VR to have a significant role in school-based education, several things must occur. These include at least the following:

- Reliable high speed, low cost multimedia systems must become available in schools. The next generation of video games, to appear in late 1999, seems likely to fulfil the performance and reliability requirements that are so clearly unfulfilled in schools by personal computers. However, their acquisition by schools depends on political and economic issues.
- An adequate theory and body of practice of instructional design for virtual worlds must be developed.

...environment that incorporates live instruction, tangible artifacts [artefacts], and careful guidance for generalization. Virtual reality is like a field trip – fun, motivating but potentially hard to relate to the curriculum.

2.3 Lack of Meaningful Content

Where content is concerned, there are further varying aims and methods. Some virtual environments are assessed in terms of ergonomics, and their effective usability (Bowman, 1997; Bowman, Johnson, and Hodges, 1999). Interestingly, few environments are directly assessed in terms of useful content (Champion, 2002; Turner et al, 2005).

Some virtual environments are assessed through how well they inspire a sense of

spatial presence, negative feelings (phobic reactions), realism or naturalism, and subjective involvement / engagement. These are generally considered factors of 'presence' or 'telepresence' ('the sense of being there' without noticing the experience is mediated by technology). This field is still in its infancy-there is still confusion and debate as to the meanings of 'immersion' and 'presence' (Slater, 1999; Lombard et al, 2000; Schuemie et al, 2001).

2.3.1 We Experience More than Tangible Objects

Writers often criticise virtual environments for evoking 'cyberspace' but not 'place'. In other words, they are attacked for lacking the richness of associations and encounters of meetings that are found in real space. Such critics include Kitchin (1998), Benedikt (1991), Johnson (1997), Heim (1998), and Coyne (1995, 1999a). However, compelling examples and prescriptive rather than just descriptive writings on what elements help create a virtual sense of place are rare.

This thesis began from the fact that, when a group of students were exploring and researching other 'virtual worlds' in order to begin developing Marinetta, they reported that all the worlds seemed empty and hollow, like stage sets. There were neat buildings in these spaces but no sense that these buildings had been built for any real purpose. The students noted that these so called virtual worlds did not seem to be worlds at all, but just architectural spaces that did not give them any feeling of worldliness. (Weckström, 2004, p. 9).

A class of Media students at Arcada in Helsinki also complained that virtual worlds were sterile (Weckström, 2004). Weckström (2004, p. 38) surveyed simulators, chat-worlds and games, including Microsoft flight simulator 2004, TRANSIMS Visualizer, Habbo Hotel, The Sims Online and EverQuest, and declared:

...a virtual world has to support the following factors: there has to be a feeling of presence, the environment has to be persistent, it has to support interaction, there has to be a representation of the user and it has to support a feeling of specific worldliness.

Another reason for sterile environments may stem from a belief that we experience reality as something objective, settled and constant. Solid and immutable objects are also easier to conceptualise and model than what fully constitutes reality. For the real world includes many intangibles, including social behaviours and mental states.

2.3.2 The World Is More than Visual Stimuli

This issue is evident even in the debate over using the terms 'virtual reality' or 'virtual environment'. For example, Bryson (1995, p. 9.2) offered the following definition:

Virtual reality is the use of various computer graphics systems in combination with various display and interface devices to provide the effect of **immersion** in an interactive three-dimensional computer-generated environment in which the virtual objects have **spatial presence**. [Bold is from original text].

Researchers such as Lessiter et al (2001), testing the effects of presence and immersion in digital environments, list the above spatial criterion as only one of four. The four criteria are physical space, engagement, naturalism or realism, and negative feelings (such as phobia, motion sickness etcetera).

There is still an overwhelming tendency of 3D virtual environment designers like Bryson (1995) to privilege spatial relations of visual representations over the other criteria found useful by psychologists such as Botella et al (2003), and Baños et al (2004). An emphasis on visual representation and realism is also not always of primary interest to social scientists, such as Gillings and Goodrick (1996), Anderson (2003), or to educationalists such as Prensky (2001), or Roussou and Drettakis (2003).

The above quote from Steve Bryson is part of his more specific argument that objects have to be related to head movement of an observer via head tracking in order to have virtual reality. He also argues that visual fidelity is not necessary to have 'spatial presence' but his definitions and examples only relate to the visual medium.

According to Bryson's argument, it would be impossible for a non-sighted person to feel a sense of presence in any virtual environment by definition. Therefore, there is either nothing that is not visual in our perceptions of reality (that cannot be simulated by virtual *visual* technology), OR non-sighted people cannot develop a sense of environmental presence.

Research indicates that multimodal display of information may be more effective than one medium (Kray et al, 2003). However, many virtual environments are purely visual as seen in the following definition by Czernuszenko et al (1997, para. 1):

Virtual Reality (VR) can be defined as interactive computer graphics that provides viewer-centered perspective, large field of view and stereo. Head Mounted Displays (HMDs) and BOOMs (TM) achieve these features with small display screens, which move with the viewer, close to the viewer's eyes.

While they do mention audio once, the emphasis of Czernuszenko et al is on the visual, not other sensory fields. Nor is 'interactive' defined as anything more than that the screen display is regenerated according to where the viewer is looking.

2.3.3 Different People See Different Things

There is another problem related to the ocular-centric tendency of virtual environment designers. They seem to have a focus not just with visual fidelity, but a loyalty to a belief that in perceiving the world everybody sees the same thing.

What we see is not necessarily physical reality, but our concept-orientated brain tells us that it is. As soon as reality gets to our brain it has already been filtered not just by our eyes but also by our previous experiences of reality. Virtually everything in our head is put into a conceptual schema, a framework. According to Weckström (2004, p. 25) this framework makes up a 'world':

The information stored in our cognitive schemas builds up our notion of how things are in the world. In other words it is a way of storing and transmitting culture....Our cultural notions are built up from everything we know and stored in cognitive schemas, created through our experiences.

Without content relating directly to how we perceive the world, an emphasis on formal realism is not creating a Virtual Reality, but a storehouse of visually represented objects.

2.3.4 Personalisation is missing

Virtual environments typically have no annotation ability; there is no record kept of user-environment interaction history. User-based goals are also inseparable from the overall model.

Most virtual environments are single-user. Where they allow several people to see each other, sharing of information is usually restricted to chat, sending files or hyperlinks; control of social interaction is limited. People being social creatures may want to interact with and be recognisable to other travellers. On the other hand, they might want some control over the quantity or even quality of social interaction.

Interaction is also crucial to learning. The approach suggested here is constructivist, as explained by Hein (1991, para. 2):

What is meant by constructivism? The term refers to the idea that learners construct knowledge for themselves---each learner individually (and socially) constructs meaning---as he or she learns. Constructing meaning is learning; there is no other kind. The dramatic consequences of this view are twofold;

We have to focus on the learner in thinking about learning (not on the subject/lesson to be taught).

There is no knowledge independent of the meaning attributed to experience (constructed) by the learner, or community of learners.

Hein (1991, para. 23) argued that interactivity in exhibits creates more engagement by allowing the user to apply the tool directly to their own life:

... I have watched adults look at a map of England at the dock where the Mayflower replica is berthed in Plymouth, Massachusetts. Repeatedly, adults will come to the map, look at it and then begin to discuss where their families come from. ...here is an interactive exhibit (even if there is little to "do" except point and read) which allows each visitor to take something personal and meaningful from it and relate to the overall museum experience. For me, the Diaspora Museum in Tel Aviv came alive when I had the opportunity to call up family genealogies on the computer in the reference center. The opportunity to view and manipulate a library of family trees covering several generations and a wide geographical distribution, gave personal meaning to the idea of a Diaspora.

2.3.5 Lack of Evaluation

Since most virtual environments are built in laboratories, they seldom reach mass-circulation. Their complexity and unique nature may hinder full-scale evaluation, especially of target audiences. Moreover, when the environments are evaluated, due to the scale or nature of the project, the evaluation findings cannot always be used to help fine-tune further environments.

However, there is also the problem that the academic community is still feeling its way as to which terms and criteria are best used to evaluate virtual environments. Part of the problem is no doubt compounded by the complexity of the subject, and by the vast range of disciplines interested in virtual environments.

There is also an ongoing debate about the scope and nature of presence itself at <http://www.presence-connect.com>. For example, Slater posted the following on the presence-connect.org discussion forum (2003, unpaginated):

There is no `true meaning` to the term `presence` ...The study of how to create emotionally rich, engaging, fantastic, entertaining, meaningful....experiences is very important and fundamental to the field of virtual environments, and to many other fields. However, the study of this is not the same as the study of pretence.

Pretence is concerned with how to achieve successful substitution of real sensory stimuli with artificially generated sensory stimuli. This also involves the requirement that people experiencing such stimuli (participants) have the power to change it, within constraints. ...The quest for high pretence in a virtual environment is not the same as a demand for high realism, i.e., this is not an attempt to `reproduce reality`. Rather the interest is on what fundamental properties must sensory stimuli have, and how must they be structured as a totality in order to produce the `pretense response`? ...

Preference is not the same as pretence. One doesn't have to like a situation to be

in it....Our only real disagreement is over the use of a label. We have been using the same label `presence` to talk about different concepts. While this conflict remains, the field cannot advance since there can be no unifying paradigm that is the object of study of the group of researchers involved. We will always be arguing about true meanings. The term presence has now become so overloaded with different interpretations and meanings, perhaps I should abandon the pretence of working in this field, and use this other term.

The above posting by Slater highlights an ongoing discussion on the nature of Presence Research. One aspect of the research shared by both those attempting realism and those attempting to create engaging (aesthetic) experiences is that they are both concerned with which key stimuli are necessary and sufficient to enable people to feel they are `there` (in a digitally supported environmental visualisation).

In fact, we could say there are three divergences of thought in Presence studies. The first, like Slater, believe that presence is acting or reacting as if one was acting or reacting to real world stimuli (a phobic sense of presence relies on evocative or phobic triggers). The second school believes presence is gained when the virtual environment is to all intents and purposes indistinguishable from the real world. This school of thought seems more and more evident in developing notions of presence. For example, Meehan, Insko, Whitton and Brooks (2002, p. 645) wrote:

We hypothesize that to the degree that a VE seems real, it will evoke physiological responses similar to those evoked by the corresponding real environment, and that greater presence will evoke a greater response. If so, these responses can serve as objective surrogate measures of subjective presence.

The third school believes that presence is best reached when the participant has an experience of great aesthetic or sensory interest, and they leave the cares and concerns of the real world behind them (Riva, Waterworth, and Waterworth, 2004).

The first aim being the most challenging would be of interest to people attempting to prove the power of the technology to simulate reality. The second aim may be useful for curing phobias or for selling products (advertising). The third aim may be useful for artists and designers. However, these distinctions are not yet widely distributed in the academic presence literature.

2.4 Summary of Implications for Virtual Travel

In this thesis I argue that VR (or, as I refer to it here, Virtual Environments), before it can go forward, needs to address several issues that have prevented widespread

realisation of its potential. In short, many virtual environments lack meaningful content due to a lack of meaningful interaction, little feedback and evaluation, no sense of place, no personalization (annotation etcetera), no filtering of data, and no ability to adjust the 'difficulty level' of the interface to suit the particular user or experience.

We have seen that there are many successful uses for virtual environments. Yet virtual environments that have the noblest of aims are too often only showcases. For example, a major portal for virtual heritage, <http://www.virtualheritage.net>, records the most popular articles, but not the popular virtual heritage models. Virtual heritage models are still not considered worthy intellectual content even by societies dedicated to their advancement.

Major conservation organisations do not know of the potential of virtual environments to preserve both the formal specifications of the objects, and their cultural associations. In 2001 (but since updated) the ICOMOS Burra Charter (1988) did not list digital media as one of the many listed media to record cultural heritage.

In order to satisfy users of a virtual environment, they need to know the goals and significance of an environment-the reasons why they should immerse themselves in virtual environments and what they should particularly look out for and attempt to learn.

Meaningful interaction seems to be a crucial issue here. Research surveys indicate that when presented with realistic visual fidelity users also expect interaction in order to be engaged (Mosaker, 2001) and others have indicated that meaningful interaction is preferable to photo-realism (Eiteljorg, 1998; Gillings, 2002).

Visual depiction of objects does not automatically lead to full understanding of the social and cultural properties of these objects. Social critics have written that in creating authentic-looking objects, our understanding of tourism has become fetishised (Crang and Franklin, 2001). Many virtual heritage sites have brilliantly detailed temples, but are missing the element that 'places' the temple in its context.

That missing element is people, and the driving forces that compelled them to inhabit and modify their 'world'. Every group of people has their own viewpoints, issues, and outlook on the world. Without understanding this specific cultural agency, there is a danger that we may see the virtual heritage site only in terms of our own cultural perspective.

This limited ability to represent social processes and 'intangible' heritage can create a second danger: the static and apparently immutable aspect of digital

reconstruction can imply a certainty of knowledge that we actually do not possess.

Too many scientifically accurate virtual heritage environments lack the ability to store interaction history. The actions and paths taken by its visitors affect a truly interactive environment. Yet many virtual environments do not record traces of what happened. Visitors may be able to change part of the environment but seldom does the environment 'remember' the visitors, their paths, actions, or discoveries.

For both these reasons, visualisation-based environments are only rough approximations for the conserving and preserving of history. Given interaction is needed in order to experience and learn about other cultures, there is still little research on which types of interaction are required.

Which varying modes of interactivity add to the experienced significance of, and engagement in, a virtual tourist environment? Do inbuilt evaluation mechanisms compare favourably to more traditional and formal feedback mechanisms when gauging engagement in an interactive virtual environment?

The survey by Mosaker (2001) on the missing elements of the user-experience of high-tech virtual reality museums is both unique and timely. There are indeed many technical issues to be resolved, but until we also resolve appropriate content issues, virtual environments may become highly usable, but they are unlikely to be useful (Davis, Huxor, and Lansdown, 1996, p. 3). In the next four chapters, I hope to show (with the focus on virtual heritage environments), that there are four major content-related issues blocking the development of useful virtual environments.

What creates a sensation of place (as a cultural site) in a virtual environment in contradistinction to a sensation of a virtual environment as a collection of objects and spaces? It may be argued that a sense of place in virtual environments is related to how much 'presence' we feel. Presence researchers have often cited and used, the sense of 'being in a place' as a test of virtual presence. While there has been long-term discussion and disagreement over the concept of virtual presence, it is a tricky and elusive subject to define. Yet there is little debate on the concept of virtual place.

For example, Biocca noted people might feel present in real, imaginary or virtual places (Biocca, 1997). Slater defined one aspect of presence as feeling that one is in another place, and not just viewing a set of images (Slater, 1999). Researchers often use the term 'place' in their presence questionnaires (Slater, 1999; Lessiter, Freeman et al, 2001; Schuemie et al, 2001). Yet presence can only be clearly defined by relating it to place, if place itself is clearly defined and understood.

Presence in virtual environments is often defined as the subjective belief that one is in a place even though the participant knows that the experience is mediated by digital media (Slater, 1999). Presence has many definitions yet the word 'place' itself has had a long history of changing meaning and usage.

When we talk of place, or a sense of place, we may mean socially or geo-physically defined locations, the feeling that one is in or surrounded by a type or kind of location, or the intensity of that feeling (some researchers ask in their questionnaires if a virtual environment felt like a 'place'). One can point to where they are on a map, they may feel spatially surrounded, or be able to say an event happened in a certain position in a virtual environment, without feeling that they were experiencing a strong or unique experience of place. In order to understand how and why people can feel a sense of presence, we need to have a clear and appropriate sense of place.

If we do not have a strong sense of presence, then perhaps we do not have a strong sense of place or a strong sense of social agency. We may have a sense of social agency in a virtual environment without a sense of place, but the events that

'take place' will be hard if not impossible to recover, retrieve, or re-enact. A sense of place allows us to locate and uniquely define cultural rituals, socially meaningful transactions using artefacts. This distinction will prove to be very important to the argument of this thesis, which intends to demonstrate that place may not be a necessary and sufficient condition for a sense of presence but it is for cultural presence.

Perhaps there are elements of real places that somehow have been left out of virtual environments. Many writers, frequently from architecture, have made the distinction between place and cyberspace. For example, Benedikt (1991), Johnson (1997), Heim (1998), Coyne (1995, 1999a), Kitchin (1998), Kalay and Marx (2001, 2003), Champion and Dave (2002).

Some of these researchers have further attempted to propose features that are needed for place making (for example Kalay and Marx, 2001, 2003; Nitsche et al, 2002). However, they have listed all the features that create a sense of place, not which features create a sense of place for specific audiences and conditions. It is obviously impractical to attempt to provide all place-making features when one designs places for specific purposes, especially considering that real world places do not typically use all these place-making elements.

Given the premise that place is a necessary if challenging part of creating a meaningful virtual environment, the question is raised as to how we can best gain a sense of place via virtual environments? In addition, which features are desirable for which occasions?

Centres researching virtual places, and especially contextual realism, include the Cultural VR Lab (University of California, Los Angeles) and the Center for Design Visualization (University of California, Berkeley). Digital Studios-CUMIS (Cambridge) focuses on the cinematic expression of space and social agency. CAEV (University of Melbourne), are evaluating modes of cultural learning via interactive elements such as dynamic environments, cultural constraints, and social agents. The University of Sydney's Key Centre of Design Computing and Cognition conduct research on agency and on-line learning via virtual environments. The University of Berkeley, and the European CAHRISMA project (also known as the Charisma Project), investigate social agency in virtual places.

Changing Places Research Group (MIT) hope to create mediated narrative enriched places. The "interactive institute" in Sweden has experimented with game engines to create interactive virtual environments, and are working on an 'intelligent street' project that reflects the cultures of its inhabitants. The Center for Virtual Architecture, (CVA University at Buffalo, New York), has recently been formed to

create multimedia versions of architectural education. Architecture HKU (Hong Kong), research digitalisation of heritage projects, while CASA at UCL (University College of London) has written reports on the inhabitation of virtual online worlds.

Research into place-making can be described as involving three stages, critiquing the absence of place, prescribing which elements of place are needed, and evaluating and extending place-making in virtual environments.

There seems to be a recent explosion of research centres that name 'virtual place' as a research topic. Yet the first stage was reached as recently as the mid nineteen nineties; and we are still somewhere in the second stage of theorising which elements of place go where.

3.1 Experiential Types of Place

Writers in architecture, urban planning, philosophy and geography have defined place in a myriad of ways. Edward Casey and Ed Relph have both written extensively on the definition of place (Casey, 1993, 1997; Relph, 1976). Casey focused on the experiential sensation of place as an extension of the body. On the other hand, Relph viewed place as that which surrounds the viewer existentially, in terms of attitude and intention. Relph defined many different types of place, and he described how each offered a mix of experiences (Relph, 1976).

The usefulness of 'place' can be considered a key feature of virtual communities in at least five major ways. The notion of place can identify and describe elements of a virtual environment through having the following features

- A place can have a distinct theme, atmosphere, and contextually related artefacts.
- Some places have the capacity to overawe.
- Place has the power to evoke memories and associations.
- Place has the capability to act as either stage or framework in which communal and individual activity can 'take place'.
- Place has the ability to transmit the cultural intentions of individual participants and social 'bodies'.

3.1.1 Place as Unique Experience

In her doctoral thesis, Ciolfi wrote the following notion of place (2004, abstract):

Place is a notion of space inextricably linked with the wealth of human experience and use occurring within it, and invested by values, attitudes and cultural influences. In other words, place is *experienced space*.

Place as a field or centre of unique associations and memories is a defining feature suggested by many writers (Lukermann quoted in Relph, 1976; Johnson, 1997; Coyne, 1999a; Kalay and Marx, 2001). Massey (1993) made the further interesting point that a place may be unique not just as a thematically unified container of individual elements, but also as a container of the eclectic combination or selection of those objects.

3.1.2 Sublime Places of Terror and Awe

An experience of a place can range right across the comfort - discomfort and protected - unprotected spectrum. The experience may be comforting (the Danish 'hyggelig' or the German 'gemütlich' refer to the special 'cosy' nature of home when outside is cold and inhospitable) or it may be uncanny, sublime, or terrifying. This spectrum may also be viewed as ranging from a secure sense of territorial possession and domestic safety, to a sense of being completely overwhelmed, vulnerable, mortal, or otherwise insignificant.

By linking to 'heavenly' architecture, Benedikt may have foreseen 'cyberspace' in the latter sense, as an environment that over-awes and inspires (Benedikt, 1991). Casey (1993) also described sites that were non-inhabitable and therefore non-places, as well as defining place scapes as places that surround and dwarf us. There seems to be several methods by which a place can create a feeling of awe, through infinite scale and size, through immutability, through materialisation of perfection, demonstration of unstoppable vast force, or through complete indifference to human visitation.

These notions are variations on the sublime, a theory of aesthetics that can be traced back at least as far as the Greek philosopher Longinus. For example, the book *Neuromancer* by Gibson (2000) described cyberspace as space without limit and with unbounded possibility. The eighteenth century foresaw unbounded space, both in the etchings of Piranesi and in the aesthetic writings of the philosopher Kant (1987) on the nature of the Sublime. The idea of 'Eternal Space' was also a favourite concept of architects (Wrede, 1983; Tyng, 1984).

3.1.3 Evocative and Atmospheric Place

Some writers suggest geography indirectly highlights our schemas of place. Relph (1976) suggests that place may be telluric, a series of projected landforms, or urban. When triggering mental associations to these schemas, Johnson (1997) argues that place is evocative, evoking remembered sensations of its previous self, or reminding the visitor of related activities or even of similar places.

Many virtual environments including computer games use the use of place as an

evoker of previous or imagined places. Yet writers who have noted the atmospheric sense of place have not yet fully described how it may be created (Neumann, 1996; Johnson, 1997; Kalay and Marx, 2001).

To understand what builds atmosphere, we may need to wrestle the attention of game designers and cinematic directors away from their consoles and cameras.

3.1.4 Place as Stage and Playground

A place can frame space, it can also suggest activity through the way it frames and positions objects. A playground is a place that suggests activity through affordance (objects that can swing, carry and move), and constraints (swings and slides compel us to move in certain ways).

Place as a matrix of constraints and affordances that act on the body and mind has been written of even by philosophers. For example, Casey (1997) seems to favour the definition of place as that which provides boundaries, rest, is unique as well as being related to the human body. Currently 'breathing' places allow us to deduce, or be compelled to act or think in certain ways. The Gothenburg law court steps by Gunnar Asplund are so proportioned that running up them is difficult—people are induced to reach the courtroom in a slow and unhurried manner (Wrede, 1983).

Place as a filter of action, rest and movement has been posited by architects such as Coyne, and geographers such as Relph. Coyne (1999a) actually suggested deliberately constructing constraints to force people to act in certain ways, a clear change from the suggestion of Novak (1991) that virtual environments be 'Liquid Architecture'.

The metaphor of place as stage can be extended from being defined as choreographing (restricting) ways in which we move while inside it (as above) to a record of individual behaviours and significant ceremonial actions.

This inscriptive and write-able notion of place could also be viewed either in terms of the unavoidable marks left by environmental change and user action (archaeologists call these 'traces'), or by deliberate attempts at communication (when these inscriptions can be layered over each other when place acts as a 'palimpsest').

3.1.5 Place as Trace and Palimpsest

Place as an artefact that records traces of its owners is a concept shared by cultural geographers, anthropologists, and archaeologists. For them, place is the interpretable staged slate on which historical interactions are inscribed by intent, accident, ritual, and habit. Deductions of historical places have allowed them to extrapolate cultural perspectives from dust, bones, and half believed tribal myths.

Some have described a place as a storehouse of users' meanings and identities, rather than that of architects' intentions.

Many writers have remarked that places when viewed as artefacts are 'trace' museums (Cantor, 1974; Rapoport, 1982; Johnson, 1997; Tuan, 1998; Crang, 1998; Beckmann, 1998; Schiffer and Miller, 1999). For Massey (1993), a cultural geographer, place is not merely a static physical background to action, but also a dynamic matrix or series of social interactions. Place is a process not a product, and can consist of multiple interpretations, conflicts, and a unique combination of borrowed histories.

Massey argued that place might be a record of social processes, consist of fluid boundaries, and be formed by internal conflicts. A place is evocative, fluid, and full of mementos from other places. To view a place as a container of x y and z dimensions is to deny it a cultural content. A place is more like a nexus, or a web. Moreover, the strands that conspire to create a sense of place are never set in stone. Place involves a setting for social transactions that are location based and task specific. For what people do will depend on where they are and what they believe, and how the place is or could be viewed by others as a component of their 'social web'.

In this sense, place is a cultural setting, it gives cultural interaction a time and a location, which means that place is time-based. In the words of Crang (1998, p. 103), "Spaces become places as they become 'time-thickened'." To extend Crang's argument, virtual environments need to remember what 'takes place'. The effect of place on humans has obviously had a variety of interpretations, but the next question is to ask ourselves which elements are needed to create a 'sense of place' in real environments.

3.2 Requirements for Creating a Sense of Place

3.2.1 Place Requires Embodiment

Places identify more and less bodily-desirable locations. Whenever we move, sit, or place ourselves in the real world, in fact wherever we are, we orientate ourselves into the best relationship of task activity, behavioural intention, and environmental features. We will sit x inches into the shade of a tree, and within a certain visual field range (close to the band, the exit, and friends), but far enough away so that the sound is not so loud.

Some parts of our walk will be windy, dry, hot, or cold, and we will subconsciously try to navigate through all these conflicting, attracting, and repelling environmental

processes and fields in the best possible way. This navigation is in a sense place making. Territory is place making, in the sense that we try to find the best possible site for all conflicting and varying possibilities.

We place artefacts in relation to our perception of how we appreciate or dislike environmental features. A bed may be close to the window but turned away from intense morning light. This might indicate the occupant is a late-riser.

Therefore, our idea of place is identifiable as a relationship between environmental features and personal or physical preferences. For example, 'placed' (patial) artefacts can indicate social relations between people and even between artefacts, such as houses close or far to each other (Schiffer and Miller, 1999).

Culturally you could measure this; find the right or appropriate spatial relationship by measuring, say, the spatial distances between people in relation to their social prestige and familiarity. So the location and placing of self is often cultural (the science is called Proxemics), as well as physiological.

Only in a virtual environment, apart from in games (where one hides behind walls and windows, and guns may have a certain range), how one places oneself does not often matter or impinge on a task. You might walk forward to examine something, but that is purely to enlarge the object under view.

The environment itself has no particular features you wish to avoid or take advantage of or manipulate. Your only consideration is if you are close enough to an object to comprehend its visual form. This is not an issue of proximity but of visual acuity, screen resolution, and rendering detail. Nothing here is culturally filtered, but physiologically defined.

The diffusion and intermingling of a range of dynamically interactive environmental forces are almost always absent from a virtual environment (to some extent, range of sight is evident in game design). Virtual space does not affect participants with dynamic environmental forces, with an interactive three-dimensional matrix of attenuating environmental influences.

In future journeys we will not stand too close to the kerb on a rainy day (so we do not get wet), we will not approach prisoners behind bars because they might grab us, and we sit down on a clean dry patch of grass. Activities, intentions, and environmental factors (climate, weather, light, dark, smell, sight, and sound), all have a range that in turn depends on the range of other factors.

The diffusion and intermingling of this range of interactive forces, is almost always absent from a virtual environment (to some extent, range of sight is evident in some entertainment). Space is x-y-z. Space is not phenomenologically dependent

on or intentionally related in strength to the distance of the force or influence from the user. Nor is digitally simulated space amplified or affected negatively by the presence of other forces or influences.

Digitally simulated space is far too rarely constrained and contextualised by the presence of other forces or influences to convey accurately the embodied experience of real places. There is thus a need for location-specific variations in perceived physiological comfort and discomfort; we pick our place depending on personal tastes in comfort, light, privacy, and view.

3.2.2 Place requires Paths and Centres

Virtual Environments lack the affordances and constraints of paths and centres. For the virtual environment is only space, it does not 'afford' placing ourselves. So we only position, we do not place (centre) ourselves. In addition, we do not traverse a sensory field. We simply walk closer to an object or we stop.

As embodied stationary objects, we place, site, and centre ourselves optimally inside a flux of forces that affect our task efficiency, our social standing, and our feelings of comfort. As moving objects, we automatically choose the 'path of least resistance'.

Perhaps not surprisingly, examples of these suggested solutions reside in architecture. Architecture modifies behaviour through symbolic cues, offers paths and centres so that we can navigate and place ourselves, and suggests the passage of time as well as records the meetings of people.

Borrowing from Venetian and Byzantine design motifs, architectural theory of the 1920s, made a distinction between path and centre, to decorate spaces of rest and eschew decoration in paths (Champion, 1993). For ornaments make us rest, and a lack of ornamentation makes us search without distraction until we find a place we can centre ourselves. Decoration indicates the goal. Moreover, formal symmetry implies a ceremonial space that is less likely to change. Asymmetry implies influence from outside forces; a less regular spatial configuration can cater better for functional tasks than for formal rituals and ceremony.

3.2.3 Response to Place Requires Ongoing Feedback

Which factors that help create a sense of place are in need of restoring? Can we recreate some of them digitally or metaphorically?

For example, we walk under an eave when it rains or when we hear thunder. How would we inspire this behaviour in a virtual world without the ability to soak the user? Could we use related triggers such as the sound of thunder?

The simulation of such 'triggers' would only work if the user thought they were in reality or a world that obeyed laws of physics completely. Following the thunder example, a user needs to be motivated by the apparent realism of the stimulus (the sound of thunder), or convinced that the stimulus had consequences for them if they did not seek shelter. Therefore, we need to aim for realism or we need to create rewards and punishments. If we opt for realism, the user will eventually lose the automatic reflex, as there is no reinforcing stimulus (i.e. they learn they cannot get wet even if they are outside and even can hear the sound of thunder).

If we opt for metaphor, depending on the level of realism, the user will also see through the analogy. There has to be a feedback mechanism somewhere that simulates dynamic environmental affordances. The question is, how can we do it?

3.2.4 Place requires Social 'Embeddedness'

Ironically, a sense of place is most apparent through its absence, especially in Virtual Environments, whether for games, for tourism, or for heritage preservation. The environments may have some simulated social interactions, but these social interactions do not richly inhabit or modify their environment. In such virtual environments people are stranded, for place does not recognize their presence. Moreover, in the real world we seldom wander around without any sense of purpose. Flaneurs and peeping toms still have a purpose, to observe human behaviour without themselves being drawn into direct social involvement.

Ah, the golden days of flanerie are gone. Saunter, stroll: dally, dawdle; loiter, linger ... arm in arm those magical words float by me, trailing their irretrievable aura. The ability to set the pace of one's own life is the elusive dream of the urban loafer. (Ffytche, n.d.).

In actuality, the flaneur remained part of society even as they rebelled against it. Places reflect this wandering aspect of human behaviour, through promenades, malls, and esplanades. For although flaneurs may have thought they were wandering completely without volition or direction, they were in fact drawn to spectacle and areas of interest. In a similar sense, virtual environments need to offer more than solely the ability to wander, in order to retain interest they must offer some degree of social agency. Coyne (1999b: last paragraph) writes:

Architecture is not only about the artefacts we see built around us, but it is about the process of designing and building, about the way we are all embedded, and embodied, in the practice/praxis that is architecture.

In a sense, people are not just physically embodied; they are also socially embedded. Their motives, intentions, and actions can be fully understood only when referenced to a social perspective that makes sense of a specific physical

environment. Recreating the objects that make up our society is however not recreating the society itself, as some of our cultural knowledge is not ostensive and is not directly tangible.

Undoubtedly, there are also many cultural and ethical issues. In the following paragraph, Sardar (1996, p. 19) describes the purely physical (or, in this case, digital) recreation of traditional societies as a typically Western phenomenon.

Cyberspace is particularly geared toward the erasure of all non-Western histories. Once a culture has been 'stored' and 'preserved' in digital forms, opened up to anybody who wants to explore it from the comfort of their armchair, then it becomes more real than the real thing. Who needs the arcane and esoteric real thing anyway?

Sardar (1996) and Suzuki (1997) and have argued that modern notions of place in Western literature may be ignorant of other cultural perceptions of place as opposed to space. Yet the obliteration or assimilation of other cultural histories is a trademark of all dominant cultures, not just Western ones.

An interesting prediction, the above comment seems unaware that culture is maintained and transformed online in a myriad of ways. Some communities administer their own cyber-worlds. Some communities require distance learning or websites to keep their own culture alive. Virtual environments can be dynamic, interactive and multi-perspectival; there is no inherent necessity for meta-narratives or Western-biased viewpoints. Nor does digital technology have to make virtual environments safe and homogenized.

Virtual environments can be abstracted multi-modal, multi-perspectival, challenging, and culturally constrained. They can choose their own form of presentation, interface, navigation, narration, and goal. It may turn out that this infinite range of interpretative possibilities and contextually related interaction is both more socially constraining *and* more engaging to participants than some bland Westernised cyberspace. Virtual environments can contain more than objects, they can also force us to be constrained by the social roles and rituals residing in the environment that has been digitally simulated.

While place is created, modified and inscribed by many varying beliefs and activities, virtual environments that offer a notion of place may appear complete and accurate when in fact they have ignored or distorted historical cultural or physical aspects of the real world. Place is a particularly difficult concept for virtual community designers, as its power lies through dynamic interaction as much as it lies through formal uniqueness or realistic detail. However, it is an essential staging device for atmosphere, for social identification, for personal orientation, and

through adding a sense of uniqueness to user driven and observed events. As an artefact, place is also a treasure trove, a map and a storehouse of human-environmental interaction. A space used as a place reflects the attitudes, behaviours and intentions of the community that owns it. Hence, a virtual place must do likewise for a virtual community.

Communities identify and are identified not just by the clothes they wear or the language they speak, or the way they greet each other. Communities are often identified by where they feel compelled to do these things, how they use spaces to construct meanings, and the traces left by their social interactions. These trigger regions are thus not just points in space, they are also landmarks, havens, homes, ruins, or hells. Communities are identified, and identify with or against, not just space, but also place. Places do not just organise space, they orient, identify, and animate the bodies, minds, and feelings of both inhabitants and visitors.

3.2.5 Place Can be Marked

Finally, a virtual environment has to be writable; a user must be able to leave their mark on it.

We have seen how in the literature a specific place gains its unique character through time and use. Place is not just adaptable, but also mark-able and recordable. It records signs of its use (user modification is persistent); it also erodes and denudes. Place is an artefact, as past events can often be inferred from it.

Through the wear and tear of graffiti, vandalism, environmental forces and human induced erosion, place is also personalised. Yet where in virtual environments, and specifically in virtual communities, do we see people leaving marks? The virtual houses that we might build in say ActiveWorlds are too crude to reflect either our activities inside it or our changing social identity. While current attempts at virtual placeness often defy inhabitation, the places that surround and structure our lives reflect it.

Having summarised some key features of real world places, the next step is study how different mediums evoke a sense of place.

3.3 Evoking Place via Arts and Sciences

Other fields of human endeavour, such as architecture, literature and film, reveal that place is often imaginatively reconstructed through suggestion, rather than through realistic attention to detail alone. Which key ideas can we adopt from architecture, literature, film and other disciplines to extend and further articulate

the role of place in virtual environments?

3.3.1 Architecture

In the creation of architecture, place is often highly referential. For example, architects skew fenestration in relation to paths in order to create glints of far off vistas. Thematic separation of internal volumes into a tapestry of paths and centres that emphasise discrete building functions, can also suggest another realm. In the writings of Nietzsche and Spengler and, from ancient monuments to buildings of the 'Heroic Modern' era, architectural environments appear to confront gravity and time.

Norberg-Schulz (2000) saw place as a dynamic unity of architectural elements that interact with inhabitants. Yet architecture is not just a collection of physical objects, it is also metaphorical, allegoric, and thematic, reliant for effect on the interactions between the building, dynamic external environment, and people along with their beliefs and values.

Alexander (1977) similarly captured the essence of interactions between humans and the environment in terms of patterns and how these patterns help form distinct places. Archaeologists decipher the meanings of past worlds by using conceptual patterns. Architecture has cultural as well as formal properties, it codifies and helps codify culturally shared responses to possible situations.

3.3.2 Literature

Various writers have expanded on how literature creates an imagined sense of place, (Relph, 1976; Casey, 1993, 1997; Crang 1998, pp. 43-58; Malpas, 1999). As with architectural symbolism, literature suggests life-worlds by the use of patterns and motifs. Unlike architecture, the power of literature to signify place rests on continual and sustained evocation enlivened by dramatic tension or by descriptive power through a fixed story line. It conjures up an emotively charged setting, it is an imaginatively reconstructive projection, and suggests place via atmosphere that is an integral part of the characters' intentions and tasks.

Constructed through textual representations and linear format, Hein (1991) has argued that literature retrieves time, space and experiences, to move a reader from being a mere spectator to a participant, by appealing to a reader's personal experiences and associations. By suggesting rather than completely describing, the book only circumscribes reality by adding in our real-time imaginings of a place. In reading a book, we are really experiencing an imaginative construction of a world based on the interaction of our personal experiences and our inferences of what is happening along with, sometimes, the authorial intention. Realistic description is

only part of the act of reading.

3.3.3 Film

Via transitions and fades, film is intentionally unrealistic (Laurel et al 1994).

Neumann (1996, p. 8) reminds us via his quote of the architect Hugo Håring, that spatial construction for film is ephemeral:

As Hugo Håring noted in 1924, "Space in film only needs to be unique, singular, designed for one event only, one instance of joyful bliss, one moment of horror."

Cinematic and linear representations mould places from a single perspective. Compared to literature, films offer a multi-sensory narrative albeit within a similar linear format, while challenging that constraint through various mechanisms such as transitions, fades, split-screens, and so on. Further, films suggest off-camera space but never show you it. By using fragmented perspectives, they coerce the viewer into believing they are both happening now, and happening in a world that encloses the viewer.

3.3.4 Cultural Geography in Place and Culture

For cultural geographers, culture has a setting and this setting is enabled through a perceived sense of place. Culture requires a setting. According to Crang (1998, pp. 1-2) culture must be "embedded in real-life situations, in temporally and spatially specific ways". Cantor (1974) notes that the interactions between these objects and their setting may be quite complex.

Culture is a feedback loop. A visitor perceives space as place, and inhabits (modifies a place), place 'perpetuates culture', and thus influences the inhabitants in turn. We might say that social behaviour is behaviour between two or more people. Cultural behaviour is a subset of social behaviour, where behaviour is governed by or understood in terms of a cultural setting. As culture almost inevitably involves transactions, there must be objects of shared transactional value.

'Place' is an important concept for virtual environment design. As I have noted earlier, place may have any of the following features: a record of social processes; fluid boundaries; and internal conflicts. It may leave 'traces' of the people who saw and used it as a place, or it may 'signpost' features that communicate something to us about how we see our place in the world. Places are often full of mementos from other places. So rather than a fixed and set experience; a place can be more like a nexus, a web of associations, cultural affordances and memories.

Thus, the old communication model of culture requiring only a sender and receiver of data is inadequate; culture is a highly interactive dialogue of human ideas

transmitted via social and individually constructed places.

In order to create culturally evocative environments, we need to understand which interactive elements disseminate cultural information.

According to Schiffer and Miller (1999), we learn about a culture through dynamically participating in the interactions between cultural setting (a place that indicates certain types of social behaviour), artefacts (and how they are used), and people teaching others how to observe and how to behave (act and react in a shared social situation), along with one's personal motives.

The only way to approach this issue is to view (and design) virtual environments depicting human cultures as hermeneutic (that afford an actively engaged interpretation of the lives and intentions of past inhabitants). The hermeneutic features of place in these environments are almost certainly more difficult to create digitally, but that does not negate their importance. Luckily, for virtual environment designers, these hermeneutic features have been described by social scientists. They maintain that people develop shared cultural perspectives of place in many different ways.

If place as location is a nexus of environmental forces or attributes, we can learn about places in the real world in relation to culture through observing human behaviour. We may even infer specific mental attitudes by the ways in which humans respond to these environmental forces.

We can learn about the significance of a place by how old or worn it appears. These cues can tell us if it is popular, venerable or abandoned. We can also tell cultural behaviours by observation, such as inference from the properties of related artefacts. For example, properties in Japan near burial grounds are significantly cheaper than other housing areas. We can learn about the significance of a place by social learning (by people telling you or instructing you). We can learn about a place through task-based activity there (for example, we learn a swimming pool is suitable for swimming).

We have now seen the role of place in the real world. The question then is how do we gain such a sense of place via virtual environments?

3.4 Cyberspace Critics and Criteria

Many virtual environments marketed as 'worlds' have limited capacity for personalisation or for customisation. They also often lack clear and precise navigation and general environmental affordances (Gibson, 1979, p. 127; Schroeder 1996; Campbell 1997). This field is still in its infancy, as some of the

most comprehensive research has been focused on combat situations (military simulations, online gaming), and not on what interaction is most engaging and usable in online communities.

In the real world, our understanding of the current locality is often coloured by the places that we have just travelled to, or that we recognise as having some relation to our current place. In much Presence research, there is talk of being transported to a virtual environment, yet participants are in fact often teleported. That is to say, virtual environments are often experienced instantly; they typically do not offer a ritual of passage or 'arrival' that allows a suitable atmosphere or expectations to build up.

Hodder (1986, p. 23) argued that "ritual regulates the relationship between people and environment", and that meaning is related to function. Tilley (1999, p. 29) agreed, noting, "Rituals not only say something, they *do* something." Childe (1956) also made the point that myths are actually important. He argued that myths are instructions to do rational things, only the instructions often carry some additional irrational steps.

Further, there is little research so far on enhancing realism or completeness by using out of world stimuli to suggest there is more in the virtual environment than what is actually experienced (Marsh and Wright, 2000). Writers have suggested adopting game engines and game-style interaction for the development of virtual worlds yet activity may create a sense of panic and reduce the level of attention paid to the enjoyment and learning of the virtual environment (Waterworth, 1999).

Coyne (1999a) has written that tasks and social agents need to be part of virtual environments, as they provide purpose, meaning, and social feedback. The danger may be that talking to people will be more interesting than the place, or the place is so intimidating or imposing that social interaction is severely curtailed.

Cultural or physical constraints may be needed to control or free the participant in naturalistic or novel ways. As environmental psychology is a difficult and complex field for concrete results, our knowledge of which significant elements control or help human behaviour in virtual environments is likewise curtailed and limited. Yet this knowledge is vital. A greater understanding of behavioural and perceptual cues helps a designer to design just enough that affords 'placeness' (Campbell, 1997).

We need to decide which real-world cues and constraints are desirable, while acknowledging that realism may sometimes hinder engagement (Laurel et al, 1994; Eiteljorg, 1998; Mosaker, 2001).

In their paper 'Cyber-Placemaking', Kalay and Marx (2001) identified eight types of virtual places or cyberspace places extrapolated from architectural and urban

design theory. For them, places are settings for events, places are engaging, afford relative location (i.e. orientation), are imbued with authenticity, are adaptable, afford a variety of experiences, provide choice and control over transitions, and are inherently memorable.

Granted, it is hard to argue with the appropriateness of the above attributes, for many writers have used similar criteria. Coyne talked of association, authenticity, activity and task-based criteria (Coyne, 1999a). Laurel spoke of the need for engagement and personalization (Laurel, 1990). Inspired by both the Memex and the Memory Palaces of Simonides, Johnson (1997, pp. 120-122) argued that the most engaging three-dimensional environment would be socially associative, interactive, and task-oriented with a 'recall' or a 'trail' of the users.

Extrapolating from anthropological stages of 'going native', Relph (1976) suggested three dimensions of relating to feeling inside or outside place. These dimensions are behavioural (observing behaviour modified by place cues), emphatic (participating in an understanding of place), and existential (feeling an integral part of a place).

Champion and Dave wrote that 'existential insideness' was one approach to place not fully covered by the Kalay and Marx paper. Their solution was to extend and apply Relph's classification to virtual places (Champion and Dave, 2002). They divided virtual environments into three major types, visualisation-based, activity-based, and hermeneutic.

They argued that the intention of virtual environments is to afford visualisation, to support activity-based tasks, or to offer an interpretative framework for different cultural beliefs, individual perspectives, and world-views. The hermeneutic environment, as they defined it, allows people to gain an idea of the indigenous social and cultural beliefs, and further allows users to inscribe the environment with the results of their own interaction with it. Champion and Dave suggested unique and personalised user action that modifies the environment would deepen time-associations and hence increase a sense of place.

We can argue that for creating a virtual heritage environment with a notion of a 'place' (a region recognizable to a user as a culturally coded setting); we need to have more than merely identifiable or evocative virtual environments. Instead, we need to create a virtual environment that evokes and identifies a place that carries cultural indications of inhabitation driven by a different cultural perspective to that of our own.

This virtual place should suggest ideas of thematically related events, evidence of social autonomy, notions of territorial possession and shelter, and focal points of artefactual possession. In other words, the virtual environment must provide a

perspective of a past culture to a user. Such a perspective is normally only deduced by trained archaeologists and anthropologists from material remains (fossils, pottery shards, ruins, etcetera).

3.4.1 Cyberspace Concepts and Terminology

A paucity of clearly defined concepts prevents designers from developing appropriate place making elements for virtual environments. The challenge of selecting appropriate place making features is not helped by the slippery (and circular) nature of language in the literature and discussion of virtual environments. Additionally, until recently many designers considered the degree of visual correspondence between real and virtual worlds as a sufficient measure of successful virtual environments.

For example, Kalay and Marx (2001) used such a scale to classify 'cyber' environments into the following: hyper-reality; abstracted reality; hybrid cyberspace; hyper-virtuality. However, terminology based solely on appearances or delivery does not explain the aims of designers, the goals of users, or the interactive content that arises out of virtual interaction and interpretation between users in their attempts to solve tasks. Indeed, apart from the magnetic attraction of ever expanding vocabularies, such terms do not even help us understand why we would want to be in those virtual environments in the first place.

3.4.2 Cyberspaces Lack Limits

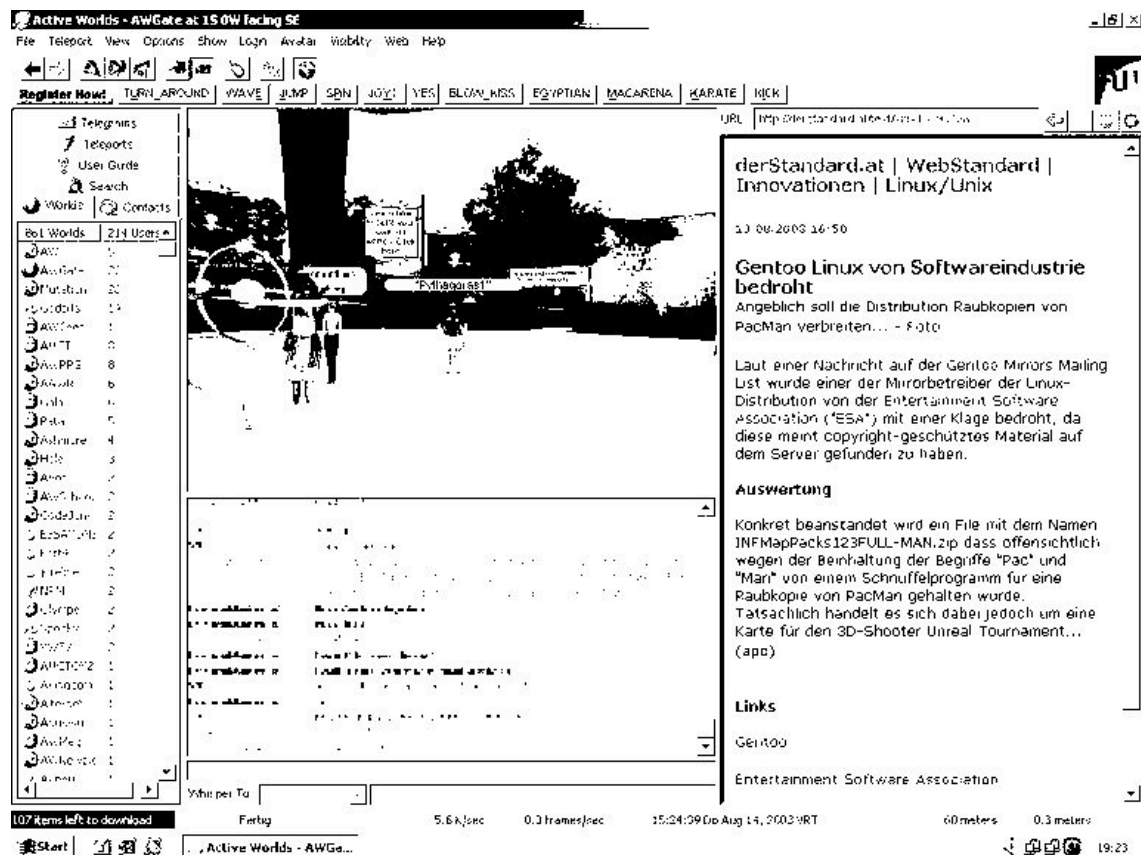


Figure 1: ActiveWorlds Screenshot

For example, “ActiveWorlds” allows one to build houses and thus might seem to have some kind of place-ness (Figure 1: ActiveWorlds Screenshot, image source: screenshot taken by author while visiting <http://www.activeworlds.com>, 16 December 2004). However, these worlds lack meaningful constraints. That is, they lack dynamic environmental or physiological features that would constrain and thus uniquely identify places.

Some users now talk of vandal police (as users could destroy other participants’ houses) but apart from that interesting social development, one is confronted with an absence of tasks, limited social interaction and movement, and an absence of any historical context (for more information, refer the CASA diary online at <http://www.casa.ucl.ac.uk/30days/news9.htm>).

The Renaissance Project does not have an exterior, agents walk around a predefined place, and one cannot modify the environment (Figure 2, image source: author). However, agents do remember user profiles, and one is given tasks to complete in line with a Renaissance book of manners, in order to become rich or famous. Still, as the place itself does not retain footprints of users, it does not seem to have a great deal of place-ness, especially as the agents could exist in any of the

rooms.



Figure 2: Renaissance Community Screen shot

According to Mosaker (2001) who reviewed Miletus and Bologna reconstruction projects, it is all architecture, no life forms. For stage sets, however perfect, do not tell us much about how people lived there. These historical reproductions reduce authenticity to the visual surface.

The above examples, on the one hand, demonstrate that place-making notions are becoming crucial in such projects, e.g., territorial demarcation in ActiveWorlds, scripted encounters through role-playing in the Renaissance Project, or reconstructions of past moments in time.

On the other hand, it is not clear if 'place' in ActiveWorlds is somehow identical or similar to that in the Renaissance Project. Neither is it clear how they are dissimilar (apart from in appearance or delivery) that might allow us to distinguish one place (if there is any) from another. Evaluation mechanisms may help.

3.4.3 Cyberspaces Lack 'Play' Through Objects

According to studies in material culture, which is advancing into the field of anthropology from archaeology, the way in which objects are used, created, and exchanged gives us not just new insight into past and long extinct cultures, but also into our own (Schiffer and Miller, 1999). Material culture theory argues that human

interaction is between humans, humans and the environment (and externs-objects that are not artefacts), between humans and artefacts, from humans to humans via artefacts and so on.

The range of interaction is also extremely broad, and in every facet of interaction, artefacts can play a major or even essential role. Hence, unlike verbal studies of culture that only account for audio research, material culture studies may offer a wide range of insights across all the domains of interactivity.

That is not to say 'Material Culture Studies' is fundamentally a visual-based research field. For example, Schiffer and Miller (1999, p. 5) argued that even though only 6-7.7 per cent of major research journals in anthropology deal with artefacts or technology, "every realm of human behaviour and communication involves people-artefact interactions."

3.4.4 Cyberspaces Lack Life History

Typically, the role of place in virtual environments has been as a locator of objects. Yet cultural geographers argue place is more a constrained and malleable container of localised activities, evoking associations of past events and stimulating future tasks. In fact, virtual environments are often criticized for evoking 'cyberspace' rather than a culturally shared notion of 'place'. In other words, they lack the richness of associations and encounters of human transactions in real space (Benedikt, 1991; Johnson, 1997; Heim, 1998; Coyne, 1999a).

Without content relating directly to how we perceive the world, an emphasis on formal realism is not creating a virtual reality, but a storehouse of visually represented objects. A possible reason why early environment builders aimed for realism rather than for content may have been a belief that we experience reality as something objective, settled and constant. Solid and immutable objects may be easier to conceptualise and model than what reality is really made up of, matter and energy interacting according to laws of physics continually interpreted by human perception fuelled by need and imagination.

However, our notions of reality are actually cultural notions of a constructed reality (Riegler, 2001). Digital simulation of objects by itself will not enable meaningful content that contextually places a virtual environment in an engaging way.

If the purpose of virtual heritage models is to preserve the culturally significant articles of the past, they must demonstrate reasons for simulating that past material culture. Yet they are generally used as showcases for technology rather than to reveal the views and beliefs of the owners of that culture. In most current digital environments, objects are not digitally simulated as objects-in use, with life

histories, with formal or associational traces. They are simply three-dimensional objects.

Even if the models did bear formal traces of a life history, of a series of interactivities (interactive activities), they fail to communicate effectively the knowledge required to infer why that particular artefact was contextually meaningful. This may be due to the difficulty of conveying the worth of objects from a different cultural background, and conveying its cultural significance, its imagined presence.

Yet an idea of cultural presence must mean that people with a similar or different cultural perspective to ours, can occupy a place, and be identified as like or unlike, by us. This sense of cultural presence should allow us to feel that we recall having, in the words of Slater (1999, p. 561) "visited a 'place' rather than just having seen images generated by a computer."

3.5 Suggestions for Creating CyberPlace

Although the criteria proposed by Kalay and Marx (2001) are useful, they do not help us to determine which design features are most important, necessary, or even desired, for different types of virtual environments. Further, they do not address several important features of place. For example, places are not just memorable but also evocative.

As Relph (1976, p. 61) noted:

The identity of a place is comprised of three interrelated components, each irreducible to the other, physical features or appearance, observable activities and functions, and meanings or symbols.

So the place-making criteria of Kalay and Marx address only two major types of environments addressed by Relph, environments that afford 'physical features or appearances', and those that afford 'activities'. The Kalay-Marx criteria, being based on modes of reality, do not address virtual environments that attempt to offer interpretations of past and present cultures. Partly this omission is because it is difficult to simulate culture, virtually or otherwise. As Tuan (1998, p. 6) wrote, "Seeing what is not there lies at the foundation of all human culture", yet virtual environments typically only attempt to simulate what is there.

I have suggested five major types of place experiences. We could summarise how to evoke these experiences in virtual places as follows (Table 1).

Table 1: Features of Real and Virtual Places

Features of real-world places	Desired features of a virtual place
Places are dynamic and changeable. Their boundaries may be vague and amorphous.	Attenuating environmental forces (for example, wind, fog, rain, directional and dynamic lighting, sound, perhaps even varying vision acuity).
Places can range from the comforting to the uncanny, the sublime, the terrifying.	Scale, detail, atmosphere replication or phobic triggers heighten the experiential realism (this term will be discussed in section 5.3).
A place is full of references and evocations of related places via the movement of people and their artefacts. It may also evoke images of its previous self, related activities, or other places.	A way of triggering past associated environments or events that the virtual environment thinks a visitor has been to. This is perhaps one of the most challenging yet interesting of place-attributes, how to create place-associations.
A place constrains, suggests and localises activities. The constraints may be highly variable, and affect the physical, conceptual, or cultural sides of human experience. This in turn means that place frame communities-you can read a place from the way it frames individual ritual and communal activity.	Tasks, events, artefacts and some degree of social agency (people), which is specifically place-associated. For example, participants may be able to move certain artefacts, but they will only be able to place or leave them in specific places, or, some interaction (e.g. skills), may be transferable across places, but some may not be. The ability to piece together understanding of a community through viewing its artefacts and the way people relate to those artefacts in certain places.
Places are recordable, they gain their unique character through the passage of time and use in relation to the ebb and flow and interaction of dynamic physical and climatic changes	The ability to be affected (modified) so that formal traces are left of the activity of interactive elements and the passing of time (including modification by dynamic and unpredictable environmental forces). Specific details (topography, textures).

The above table summarised how five types of place-experiences may be conveyed via digital media by analysing which real world experiences of place are left out of virtual environments.

Yet this approach may compel the designer to overload their virtual environment with every possible place feature. The danger of such an approach appears to be already happening in some of the academic literature (Nitsche et al, 2002; Kalay and Marx, 2001, 2003; Kalay, 2004).

Real world places only have some place making features, and practical considerations suggest we only create those place features that most effectively trigger the required sensation of place. With this in mind, we can also approach place-experience through designing for different types of audiences and intentions.

3.6 Three Types of Virtual Environments

Instead of using the Kalay and Marx taxonomy, which relies on a degree of visual

correspondence between real and virtual worlds to discuss place, I proposed a matrix derived from an observation of both real world place experiences and virtual environments (Table 1).

Such a graduated categorization, on the one hand, allows us to correlate place-making features to general aims of virtual environments. On the other hand, it also suggests that a hermeneutic virtual environment (one that has to be actively interpreted by a participant), is the most difficult to engender.

3.6.1 Inert 'Explorative' Environments

The first and most common type of three-dimensional virtual environment available on the Internet is the visual (sometimes with sound). An extension of the scripting language used to write web pages (HTML) was developed in the nineties to create the sense of three-dimensional objects on a webpage. This language was called VRML (and confusingly either pronounced V.R.M.L or 'Virmil'). It was difficult for non-programmers to learn and required a great deal of effort to make interactive. Worse, it was very slow. One of the great hyped technologies of the Internet, it never truly took off (Parisi, 2001, p. xxxviii).

VRML environments were good examples of the limited interactivity of virtual environments that targeted visualisation. One can walk around objects, magnify the view or pan the camera around objects (say buildings), occasionally move between preset viewpoints, and that was about it. Orientation and view were often manipulable, but the environment was not truly interactive, as it did not affect the participant's actions, or could be modified by the participants. However, visualisation-based environments do have their uses. For example, they can be used to create a three-dimensional fly-through of a building for an architect's clients. The advantage and disadvantage is that the environment is only a finished product: it is not affected by inhabitants, and so manages to be definitive, immutable, and appear consistent in appearance.

Due to the success of these architectural computing-based models, it has been suggested that Virtual Environment design be informed by architectural and planning theory (Kalay and Marx, 2001). It might be argued that Computer Aided Draughting (CAD) applications are directly synonymous with building three-dimensional digital environments and therefore the CAD programmes used by architects are tailor-made for designing virtual environments.

The problem is that CAD was designed to get buildings built, to quantify rather than qualify the architectural experience. They show static additions to the environment, rather than environmental changes acting and interacting over time. There is no fog, no dirt, no wind, and often even no people. Yet the real world experiencing of

architecture is always mediated through a dynamic and imperfect sensory interface: our minds and our bodies.

Computer reconstructions created from CAD programs typically do not allow for sensory cues, illusions, and limitations. The suggestion of dissolution of form, of mood (often through dramatic lighting), of multiple thematic interpretations, or personalisation and the erosive effect of time are generally missing from virtual reconstructions. These factors, along with limited interactivity in general, may help explain why few virtual heritage environments are popular or engaging, especially when compared to chat-worlds or to computer games.

Lack of atmosphere is not the only issue. Virtual heritage environments are designed to preserve historically significant archaeological sites. Conserving and preserving a sense of history is an important and difficult task. Part of the problem is that history is not a static and immutable object, but a dynamic mass of interpretations, actions, intentions, and beliefs.

Every group of people has its own viewpoints, issues, and outlook on the world. Without understanding this specific cultural agency, there is a danger that we may see the virtual heritage site only in terms of our own cultural perspective. This limited ability to represent social processes and 'intangible' heritage can create a second danger: the static and apparently immutable aspect of digital reconstruction can imply a certainty of knowledge that we actually do not possess.

In addition, too many scientifically accurate virtual heritage environments lack the ability to store interaction history. The actions and paths taken by its visitors affect a truly interactive environment. Yet many virtual environments do not record traces of what happened. Visitors may be able to change part of the environment, but the virtual environment seldom 'remembers' the visitors, their paths, actions, and discoveries.

For these reasons, visualisation-based environments are of limited use in designing virtual heritage environments that conserve and preserve history.

3.6.2 Activity-based environments

Activity-based virtual environments allow activities to take place. Many are games or training programs. More than a straight visualisation of objects, an activity based virtual environment allows one or more users to alter some character or element in pursuit of a defined goal. Video games such as Pacman are activity based, as are Tic-tac-toe and Microsoft's Flight Simulator game. Activity-based virtual environments are arguably the most commercially successful type of virtual environment.

The technological limitations of internet-available visualisation-based virtual environments (such as VRML 'worlds'), do not seem to have hindered the popularity of complex games. The most popular form of virtual environments is arguably the computer game. Entertainment software is the fastest growing of all types of entertainment, outselling films. The computing power of current game consoles also rival supercomputers used a mere decade ago. Computer game engines are also used for research into artificial intelligence.

Games can have 'atmosphere'. There are tasks to complete, navigation reminders, inventories, records of interaction history (such as damage to surroundings), and social agency (such as real or computer directed opponents). Most popular games contain a personalized representation of the user (known as an avatar), and similar representations of allies and opponents. In creating effective virtual heritage environments, these features of games could be used. They could be designed around a task or goal, and include visual representations of the users and other significant characters.

3.6.3 Cultural or 'Hermeneutic' Environments

In order to create a virtual heritage environment with a notion of a 'place' (a region recognisable to a user as a culturally coded setting), we need to have more than merely identifiable or activity-based virtual environments. A place can also carry cultural indications of inhabitation driven by a similar or different cultural perspective to that of our own. A virtual heritage environment must allow us to see through the eyes of the original inhabitants, or at least feel that this place once belonged to someone else.

Hermeneutics argues that we must grasp the world of the interpreter as well as the world of the interpreted in order to gain the meaning of the text or an artwork. For example, the philosopher Hans-Georg Gadamer wrote that language is inter-subjective, exemplified by how children learn. Children learn by seeing how others respond to them: learning is an interactive process; a language itself constitutes our life-world. To quote Gadamer's translator David Linge (Gadamer, 1976, p. xii), "the hermeneutical has to do with bridging the gap between the familiar world in which we stand and the strange meaning that resists assimilation into the horizons of our world."

Table 2: Place-Based Typology of Virtual Environments

Type of virtual environment	Relph's categories	Features	Personal / Cultural Attachment
Spatial Visualization	Existential outsidersness (Objective)	Locational (links)	Locates setting.
		Navigational (orients)	Locates paths, and centres.
Activity-based	Vicarious-behavioural-empathetic insideness (Activity and Events)	Memorable (unique)	Has uniquely occurring events.
		Territorial (protects)	Locates shelter; repose in regards to dynamic environment.
		Modifiable	The artefacts and surrounds can be modified.
Hermeneutic (Symbolic)	Existential insideness Culturally coded	Supports an idea of agency-directed symbols, these reveal secrets of the environment.	
		Abandoned inhabitation.	Evokes an idea of social agency and past inhabitation.
		Lived-in inhabitation	Supports interpersonal social behaviour through human and or computer agents.
		Home	Affords personal shelter, primary orientation, identification, possession and collection of artefacts.

According to the preceding table (Table 2), the simplest stage of visualisation is capturing and manipulating and visualising three-dimensional objects, a more advanced stage is the ability to navigate through landscapes. Technology now allows us to capture adequately realistic detail, and to mimic more accurately physical laws, so this type of digital environment, while achievable and useful for various scientific purposes, only represents spatial configurations and navigation through them. The second type of virtual environment, the one that affords activity-based interaction, allows a more interactive form of wayfinding. Tasks can be completed inside the environment through interaction.

Computer games and flight simulation perhaps best convey this type of digital environment. However, only if the environment evokes a notion of other people interacting with the environment in ways similar or dissimilar to us, does the digital world begin to form.

A hermeneutic environment requires the ability to personalise and communicate individual perceptions through artefacts, and the more deeply this cultural communication can be unselfconsciously expressed through our modification of our

surrounds, the more this environment becomes a dwelling, a home, a place.

The degree of complexity of such a virtual environment may range from merely believing people with a different world-viewpoint existed in an environment, to feeling that we are being rejected or assimilated by another culture, to feeling that we are 'home'. At time of writing, I know of no virtual environment that can compare in emotional attachment to a real world home, and hence we argue that this is the most difficult type of virtual environment to create.

However, we can test for 'mild' hermeneutic immersion in a virtual world, where a participant begins to use and develop the codes of other cultures in order to orient and solve tasks, and to communicate the value and significance of those tasks and goals to others. The particular type of virtual environment that might be required thus depends on the amount and intensity of cultural perspective that needs to be generated and conveyed.

3.6.4 Matching virtual environments and technologies

In order to choose an appropriate technology, we need to determine the extent of place making features necessary to convey the required information, be it for visualisation, activity-based, or for hermeneutic understanding (Table 3).

Table 3: Virtual Place Interaction and Place Features

Virtual World	Goal	Interaction (over time)	Feature
Observational (audio visual worlds)	Navigate, and recognise.	Physiologically Inactive to Reactive.	Objects, background, navigation metaphors, time recording (sometimes).
Process-driven (activity worlds)	Enact, test skill level, learn.	Physiologically Reactive To Intentionally Proactive.	As above plus artefacts, performance recording
Hermeneutic (Culturally / personally identifiable worlds)	Inhabit, identify otherness (alterity), and communicate.	Personally and socially symbolic.	As above plus it affords the perception that one can either personalise artefacts or that artefacts have been personalised by distinct individuals or societies.

As virtual environments typically involve spatial representations, it would help to consider the overall form. Is it to be a self-contained object, an object in the landscape (similar to theatre in the round), as a frame filtering you from the external view (as in a panorama), or as a complete world? Architecture as a self-contained but externally realised object can be embedded directly in a webpage, and it can allow for annotation (audio or visual) via mark-up technologies tied to an external database.

Objects in landscape offer the opportunity to bury markers (annotations) in culturally coded ways supported with spatial and temporal databases. They can be

made more powerful with realistic recreations of weather patterns as well. The frame and panorama idea allows hyperlinked objects, the tracking of x y z coordinates, and the selection and hence annotation of three-dimensional objects.

This technology could be used for visualisation of plazas, open spaces, and interior spaces (but not so convincingly together). However, for the inside-outside evocation of architectural form game engines are more powerful. Breaking down the environment into cells, game engines support real-time interaction, particle physics, fully interactive artefacts, dynamic physical environments, multi-user participation and chat logs. They may also allow for annotation and personalisation (if only via gun scorched walls and corpses), simulated weather conditions, as well as terrain modelling (see for example game engines such as Unreal, Quake, Max Payne, Crytek, PlaneShift, Torque, Black and White).

The first type of environment surrounds and orientates us (it has spatial presence). It allows us to visualise things. The second type creates a background in which activity is possible. It allows us to do things (it allows for interaction).

The third type of environment identifies us and our personal form of physical embodiment through how we modify artefacts and the environment. Alternatively, it identifies and helps us understand the identity and intentions of other intelligent beings through how they appear to have modified artefacts and the environment. For either purpose, it caters for symbolic interaction. This third type of environment is thus like a symbolic stage or palimpsest. It may either allows us to express our identity and intentions to other people, or it allows us to feel that we can interpret identity and intentions of others through how they appear to have modified and personalised the environment to better express themselves.

3.7 Summary of Place Theory

This chapter argues that a sense of presence in virtual environments and real experiences is not just a consequence of being surrounded by a spatial setting, but of being engaged in another place. A place is particular, unique, dynamic, and memorably related to other places, peoples, and events, and it is hermeneutic.

This thesis proposes that the broad objectives of virtual heritage environments are to impart the significance of a place, and its importance to local cultural values and perspectives. Two major related issues would then be how we best convey both a sense of place and a sense of cultural presence in the experiencing of virtual environments. Yet surprisingly, they are often not discussed. The most accurate, realistic and powerful virtual heritage environments do not necessarily produce a

corresponding increase in user enjoyment (Mosaker, 2001). Such research indicates that lack of engagement with cultural perspectives of the past may have been due to a lack of meaningful content rather than a lack of realism.

It has been suggested that Virtual Environment design be informed by architectural and planning theory. However, places are not just built environments; they are lived and inhabited by non-designers. The interaction of environment dwellers and visitors give place their final character. Design by a single mind will not cover the complexity and contradiction engendered by those that are affected by place. Moreover, the pristine nature of digitally simulated or abstracted environments often lacks the blur between clear form and infinite space that creates mood and character (Neumann, 1996). Real world built environments are often vague and amorphously designed, as well as incorporating deliberate illusions to tease evoke or trigger our perceptions and memories.

Place is particular, unique, elusive, dynamic, and memorably related to other places, peoples, and to events (tasks and happenings). Place may also have a cultural and personal significance as well as a social history shaped by how it helped, hindered, and was modified by humans. Place may also act as a decipherable record of human interaction (a 'history').

Some of the most effective constraints in both physical and virtual realms that offer and often dictate behavioural cues are derived from the dynamic nature of real-world environments. Modelling such dynamic environments can range from shelter and familiar territory, to a hostile world where survival is dependent on task completion, artefacts collected, and their impacts on users' abilities.

The dangers and opportunities of the environment could be contextually related to the local cultural perspective. Some parts of the environment may impede the progress of the user in order for the user to recognise trails and paths, and socially accepted ways of travelling through the environment. The other parts of the environment may be deleterious to the avatar's metaphorical health, in other words, they act as constraints.

To encompass all the above features of various places into cyber places is a huge and currently impossible undertaking. One possible solution is to adopt a more graduated approach for understanding features of different kinds of virtual places, and the cultural and social functions they facilitate, in order to guide selection of appropriate interaction, content, and technology.

In this regard, Kalay and Marx articulated eight specific notions of place that are missing in virtual environments (Kalay and Marx 2001). However, Champion and Dave (2002) have previously argued that these features were important but not

comprehensive. The Kalay-Marx criteria, as they are based on modes of reality, do not address virtual environments that offer interpretations of past and present cultures.

This thesis instead offered a categorisation of virtual environments (derived from Relph's tripartite notion of place). These categories were the observational (visual), the activity focused (such as games), and the hermeneutic (capable of transmitting cultural perspectives between users, and between past and present inhabitants).

There are still many issues and problems with the above theories. The first is how realistic places need to be. A key issue in the creation of place is whether the goal is to reproduce accurately aspects of the real world or to create virtual environments that defy, extend or inspire our concept of what is real. There is ongoing discussion in presence research, for example, over whether the term 'presence' measures subjective or objective sensation of being in a simulated or abstracted virtual environment (refer <http://www.presence-connect.org>).

To approximate reality requires settings for social transactions that are location specific and task specific (elements that help define a place). Although designers are hindered by a lack of haptic interfaces, there is also a need for transition zones of perceived physiological comfort and discomfort (navigated and defined by user-perceived paths and centres). Yet these elements though they may help create a place, do not necessarily create a hermeneutic environment.

Finally, especially in light of a community, a virtual environment has to be writable; a user must be able to leave not just their footprint but also their 'mark' on it. For a comprehensively hermeneutic environment requires ciphers indicating cultural agency, and these ciphers, marks, glyphs or artefacts must appear to afford some form of interpretation. This notion of cultural agency and the related notion of cultural presence is the subject of the next chapter.

4.1 Confusion over Cultural Presence

Recent research has stated that lack of engagement in a virtual environment is due to technology or application issues, but virtual environments that aim to preserve explain and inform on culturally significant places need to do more than replicate objects; they need to replicate the processes that made those artefacts culturally significant.

Virtual heritage environments are far too often examples of this lack of meaningful interaction (Mosaker, 2001). Many writers have stated that virtual environments lack meaningful content, and virtual heritage environments are a case in point. "VR systems do not offer an alternative 'reality'; they do, however, provide simulated worlds that seem 'realistic,' " (Schroeder, 1996, 115).

There is a great deal of research still to be done on what social and cultural cues are most significant to people and which most aid education and engagement. These factors vary according to the audience, their background, beliefs, and intentions. Due to the gestalt-nature of cultural understanding, it may not be enough to experiment with restricted content, research on cultural presence may require significant and contextually appropriate content.

We still do not have agreed definitions of cultural presence or data to help determine which elements most aid a sense of cultural presence. We do not know, for example, which interactive features and type of cultural agency are most preferable, most informative, or most afford a sense of place as a cultural setting. Even the evaluation of cultural presence, cultural understanding, and cultural learning is problematic. We do not have a clear mutual understanding of what exactly is cultural information and how to provide for it or communicate it digitally. The first step is almost certainly to aim for shared acceptance of terms and methods, such as of cultural presence, social presence, and co-presence.

4.2 What is Culture?

Culture consists of patterns, explicit and implicit, of and for behaviour acquired and transmitted by symbols, constituting the distinctive achievement of human

groups, including their embodiment in artefacts; the essential core of culture consists of traditional (i.e. historically derived and selected) ideas and especially their attached values; culture systems may on the one hand, be considered as products of action, on the other as conditioning elements of further action. (Kroeber and Kluckhohn, 1952, p. 357).

Jenks (1993) wrote that most definitions of culture include the notion of organized knowledge and the use of symbolic representation. He noted one reason for the confusion is that culture is often used to separate, as between humanity and nature or between humanity and machine, and to unify, culture as that which humans have (and animals do not). Historically culture may be a level of perfection (a person of culture), a stage of social development (a society with a developed culture), the collective works of art and intellect (the cultural output of a society), or the way of life of a people (their cultural traditions and social perspectives).

In contrast to culture as an organization of knowledge via symbolic representation, culture is rules-based, according to Bourdieu (1984). For Crang (1998, p. 57) culture is defined as "sets of beliefs or values that give meaning to ways of life and produce (and are reproduced through) material and symbolic forms." Crang extends Sauer's early writings and remarks that landscape is a 'palimpsest'. Crang argues that culture is spatially and temporally embedded. Anderson notes culture was seen to refer to non-western people and to elites as in 'high culture' (Anderson, 1997; Crang, 1998, p. 47).

Tuan wrote that place "helps us forget our separateness and the world's indifference. More generally, culture makes this amnesia possible. Culture integrates us into the world through shared language and custom, behaviour and habits of thought." (Tuan, 1992, p. 44).

These definitions do share similar features. Culture is in some way socially created, defined and managed. Culture is expressed via language and artefacts, and culture is both vaguely bounded and open to interpretation. To demarcate the boundaries of culture clearly and accurately is thus highly problematic.

Culture is an intangible connection and rejection of threads over space and time. How cultures are spread over space and how cultures make sense of space is thus interdependent. A visitor perceives space as place, place 'perpetuates culture' (frames it, embeds it, erodes it) and thus influences the inhabitant.

4.3 A Culturally Significant Place

We could consider a virtual heritage environment to be a representation of a culturally significant place. Scientists can learn about a place from artefacts,

environment, size, scale, form, location (placement in landscape), and relation to other built forms. These cultural cues may help the designers of virtual heritage environments to layer the environment with historically based beliefs, intentions, and interactions of past inhabitants. For culture and place are entwined.

Cultural significance is a concept which helps in estimating the value of places.

The places that are likely to be of significance are those which help an understanding of the past or enrich the present, and which will be of value to future generations. (ICOMOS, 1988, Section 2.1 Introduction, para. 1).

If culture is or can be seen as a web of behaviour or system of meaning, then the significance of a cultural place is how richly and powerfully and singularly it emphasizes, filters, and directs a certain culture's way of behaving. Moreover, by extension, cultural presence is the strength to which the uniqueness of that culture is perceived through the experiencing of that place.

Designers of virtual communities may also use the detective-style methods of archaeologists and film directors to provide their 'worlds' with the ability to leave traces and artefacts of its users, and to provide the setting with a mood, an atmosphere.

Can we provide understandable cultural cues in a Virtual Environment? The answer is yes if we could create cues that inspire people (travellers, tourists, or role players) to behave in similar ways to the way they behave when confronted by real-world cultural cues and settings. If people were now to engage in a virtual environment, one would expect a series of rich and clear cultural settings and or cues that would induce certain response behaviour.

Would cultural cues add to engagement? If a sense of presence is enhanced by a sense of social realism (cultural learning being a subset of social behaviour); then creating a cultural context with these cultural cues would add to the engagement of the 'actors' (actual people participating in the virtual environment).

Would these cues be an improvement to learning, say, over traditional media? A related question would be whether the participants would learn more from a culturally encoded virtual environment than from a typical virtual environment, or perhaps even from traditional media information.

Therefore, there were at least three major questions to be answered if we wish to evoke the sense of cultural presence. These questions are as follows: how is cultural coding possible? Secondly, how is it value adding (in terms of entertainment)? Thirdly, how is it educationally significant when delivered through digital media? In order to answer these three questions, we have to have a theoretical model of cultural learning.

4.4 How Culture is learnt

When we visit other cultures we often learn cultural perspectives through copying others' behaviour, through listening (to their language, to their myths and music), or through reading text and viewing media (as tourists and students). When we visit cultural heritage sites as social scientists, we also develop pictures of the past inhabitants. This is done through deducing patterns of behaviour from artefacts, knowledge of other comparative cultures, changes to the landscape (anthropologists and archaeologists).

Table 4: Ways in which we learn about a cultural context

Real-world cultural learning	Suggested Methods for VE cultural cues
The ways in which humans collectively respond to environmental forces.	Location-dependent filters or clues for allowing you to interactively solve a task
We can learn about the significance of a place by how old or worn it appears.	Ability for attrition and user-role based erosion of place.
Learning about a place through task-based activity there.	A variety of tasks relevant to the progress and enjoyment of the user.
The properties of ritual and habitual-related artefacts.	Allow for audio or visual cues in artefacts event-driven and or location-driven.
The significance of a place by social learning (by people telling you or instructing you).	Computer-scripted agents that answer certain questions, and remember who passed by and what they did, ability for potential users to leave messages for each other.

We learn about a culture through dynamically participating in interactions within its cultural setting (Place). That is, through artefacts (and how they are used), and through people teaching us social background and how to behave (through dialogue devices such as stories and commands), along with our own personal motives. As we have seen from above, one can gain an idea of a culture indirectly, through artefacts (Schiffer and Miller, 1999, pp. 12-16).

In the real world, we learn culture socially, through other people telling us how to behave, or advising us when what we have done is not in accordance with social beliefs (Table 4). Therefore, there are two major ways of transmitting culture: through other social agents (through the language, actions, and reactions of other people), and through artefacts (the objects created and modified by people).

4.5 Social and Cultural Presence

Presence has been defined as being in a place that has some present meaning to the viewer (Slater, 1999). This thesis suggests a new definition of cultural presence, a feeling in a virtual environment that people with a different cultural

perspective occupy or have occupied that virtual environment as a 'place'. Such a definition suggests cultural presence is not just a feeling of 'being there' but of being in a 'there and then', not the cultural rules of the 'here and now'.

A sense of a cultural presence, when one visits a real site, is inspired by the suggestion of social agency, the feeling that what one is visiting is an artefact, created and modified by conscious human intention. For example, when one visits a cultural heritage site of a long since lost people, signs and audiovisual tapes prompt us to look at specific items, and tell us the cultural significance of that site to its now deceased inhabitants.

Yet to social scientists on a dig, a site visit evokes images of the past, for them the place itself is a cultural artefact. They extrapolate a sense of the cultural presence that once inhabited and modified the site. If we were trying to create a virtual heritage environment that engaged and educated people, we would be aiming at eliciting this sense of cultural presence. Therefore, in this sense cultural presence is a perspective of a past culture to a user, a perspective normally only deduced by trained archaeologists and anthropologists from material remains (fossils, pottery shards, ruins, etcetera). They recreate an idea of place from broken objects and expert deductive knowledge not immediately available to the public.

Anthropologists can set out the condition of building: they can tell us what people expected from them in the past; how they interpreted what they saw and experienced, even about the most obvious pieces of a building – doors and windows, walls, roofs and floors; how the experience of each part related to the whole – as the building, the district, the city were walked through, penetrated, integrated by use, their fragments compacted into a body. (Rykwert, 1996, p. 6).

If a robot was created and abandoned without defined rules or human contact, it is unlikely to attempt to express itself through artefacts left from the wreckage of past civilizations. For adherence to cultural rules and mores are ultimately socially governed. It is the acceptance or condemnation of other people in a society that separates cultural behaviour from individual habits. Even on a desert island, a human would endeavour to live according to his or her previous mores, in case people returned. Humans seek social affirmation.

For if a person were to be left on a desert island, the amount of information they garnered from the leftover artefacts of previous inhabitants would reflect their understanding of the local level of cultural presence. Cultural presence may also be of currently existing cultures. A tourist who is lost in a market in an exotic town but manages without understanding the local laws, language, or custom, to suspect the sellers are from a separate tribe, may have some sense of cultural presence.

To improve our understanding of cultural presence, and why it is missing from

many virtual environments, we need to distinguish it from co-presence and social presence. Many research papers that have 'culture' in the title do not clearly distinguish cultural presence from social presence (Greeff and Laloti, 2001; Riva et al, 2002; Riva et al, 2004).

It is also not clear that we can say social presence is a group of people in a virtual environment aware of each other, because the general and more specific meaning of a society is of one with shared values beliefs and/or identity. Further, people in a chat room may be experiencing social presence, without feeling that they are experiencing a strong sense or level of cultural presence.

Schroeder (2002) distinguished between co-presence ("the sense of being there together") and social presence, although he seems to think the latter is an individual's experience of being with another in a virtual environment, or, describes how well the medium helps generates this experience. He does note that this feeling does not describe what is done together or how well, which is important, as the range of interaction in shared virtual environments is actually very limited.

However, he does not draw the conclusion that social presence is limited as interaction is limited and that therefore more research is needed on what affords social presence. We could add that one significant aspect of social interaction is via culture. Culture is a way of transmitting social beliefs in a more permanent form than by random dialogue. Culture requires interaction and inscription into the virtual environment, it requires musical instruments, pens, brushes, and materials that can be sculpted, inscribed, and imprinted. Culture leaves marks; it requires an indirectly socially interactive communication medium.

Swinth and Blascovich (2002) reviewed definitions of social presence, from being together in a virtual environment, to having a sense of another intelligent being in a virtual environment, to feeling that one is communicating directly to another person without acknowledging that technology is creating this impression. They state that after nearly thirty years of research the boundaries between co-presence and social presence are still ambiguous and unclear. Swinth and Blascovich (2002, p. 319) write:

[Co-presence is]...a person's perception and feeling that others are co-situated within an interpersonal environment...social presence can be thought of as whether or not there are social cues that signify the presence of others within some interactional content, copresence might be better thought of as one's perception and awareness of those social cues and the corresponding feeling, sense, or belief that others are "there".

An unwieldy definition, it does make the crucial point that the realization others are 'in' the same virtual environment does not mean that one can socially interact with them. However, their slightly changing definitions on the next page confuse the

issue again. Swinth and Blascovich (2002, p. 320) here defined social presence as “the actual, imagined or implied presence of others”.

No, this is still co-presence; two people in a virtual environment from different languages and cultures may not know how to understand each other. Only when they manage to communicate or interact as intelligent beings in a meaningful and understood manner can we agree they have a comprehensive sense of social presence.

Alternatively, perhaps social presence also occurs when an observer can see social interaction taking place between two intelligent beings (for surely an observer can perceive social interactions of virtual ants). Hence, we have an emic and etic spectrum of social presence.

The emic social presence is the degree to which someone feels part of potential or actual social interaction with at least one other being also capable of social interaction. The etic degree of social presence is the degree to which they see social interaction (mutually perceived and understood) between two or more intelligent beings. In addition, the social interaction can range from full inclusion to full exclusion—the exiling of dangerous citizens from ancient Greek city-states was an act of exclusion but it was still a social act.

Heeter (1992) argued for a personal presence, social presence, and environmental presence. The former is how much you feel part of a virtual environment, social is how much others exist in virtual environment, and environmental is how much the environment acknowledges and reacts to the person in the virtual environment.

This thesis suggests that we further need a distinction between active presence and passive presence, and it has also added a different form of social presence, ‘How much I notice people affecting each other’. We can be aware of social interaction without feeling part of the society itself. Heeter seems to be conflating awareness of society with social awareness, *and* social belonging. They are all different categories (refer Table 5).

Table 5: Social Presence As It Affects 'Being There'

Factors in 'Being There'	Awareness of Self	Awareness of Others
Self presence	The degree my presence affects others.	The degree others presence affects me.
Social awareness	How much I notice society affecting me	How much I notice people affecting each other
Social identity	How much I identify with society	How much others think I am part of society

4.6 Hermeneutic Richness, Cultural Agency

Being able to observe a distinct cultural presence does not necessarily indicate a great amount of cultural learning has taken place. In order to evaluate the effectiveness of cultural learning there needs to be a measure of the cultural 'immersivity' of a virtual heritage environment. For want of a better term, this thesis suggests Hermeneutic Richness: The depth and vividness of a medium that allows for interpretation of different cultural and social perspectives as judged from an emic or etic viewpoint.

Hermeneutic richness does not mean photo-realism, or social presence. If cultural presence is a measure of how deeply a cultural force is perceived to imprint or ingrain itself on its surroundings; hermeneutic richness may be the depth of affordance that a virtual environment gives to the interpretation of a natively residing culture in that virtual environment.

Hermeneutic richness may allow awareness of cultural presence, or awareness of one's own ability to express oneself symbolically to oneself or to others in the virtual environment. In other words, it is the range and intensity of overlaying interpretations afforded to a visitor through a virtual environment which either

- (i) Allowed a culture to express itself symbolically through its modification and augmentation of the local environment and artefacts, or
- (ii) Allowed one or more individuals to express or reveal (to others or to themselves) their personal identity, values, and expectations.

Cultural presence can only happen with version (i), if we perceive a cultural framework when afforded a virtual environment with hermeneutic richness.

Otherwise, we perceive social agency, as in an auteur, the sense of another person expressing themselves and their relation to their world through their symbolic interactions in the environment, but we do not perceive cultural presence.

For example, one could test the richness of cultural presence in a digital place by placing a highly sophisticated and fast-learning artificial intelligence (AI.1) in a

digital environment. The length of time AI.1 can enjoy exploring the world gives an indication of the sensory richness of the place. More importantly, the length of time it can learn from interaction in the digital environment without being bored gives one an idea of the richness of the interactive experience.

However, there is no social agency; at no time does the artificial intelligence develop an idea of an 'other'- of a foreign social agent. This lack of social agency may be resolved by creating a different type of artificial intelligence (AI.2) and placing it in the same virtual environment, which results in social encounters between AI.1 and AI.2.

Yet only if AI.1 and AI.2 develop a common understanding (hopes, dreams, and fears) of the world, and they manage to interpret and share that understanding via artefacts, can we say that there is an emergent cultural agency and cultural presence. Cultural presence exists via artefact-mediated communication between social agents (the creator and the recipient), even when the creator is not there. The ability of an artefact to convey a sense of that creator's agency is a reflection of its 'hermeneutic richness' (akin to the archaeological notion of the 'trace'). The perceived sense of that creator's agency through an artefact is itself cultural agency. For an artefact is itself a cipher, a mark of cultural agency.

This hermeneutic richness is passive if AI.1 can observe and understand it. It only becomes activated if AI.1's survival becomes directed by it. In an online community, active hermeneutic richness may be a possibility and some degree of perceived social agency is a necessity. However, in a historic situation we are dealing with what was communally shared, not with what is currently shared and participated in. Completely free user-based interaction contaminates historic authenticity. It may also damage the hermeneutic richness that suggests past cultural frameworks, which is necessary for a sense of cultural presence. In order to evoke cultural learning of a historic nature, this passive 'hermeneutic richness' is the elusive and intangible quality one should aspire towards.

4.7 Culture in Virtual Worlds

...all people live in cultural worlds that are made and re-made through their everyday activities. (Agnew, 1999, p. 90).

A cultural place via cultural characteristics identifies its inhabitants. We can digitally recreate a built form, but how do we recreate a web or system of behaviour? The only behaviour system online is via forums and chat rooms, and apart from dialogue, interaction is very limited (Schroeder, 2002). One might well ask if 3D chat rooms add any significant filters or cues to a system of behaviour (Johnson,

1997).

There has been little online reconstruction of cultural heritage of traditions. We have data, multimedia applications and three-dimensional models, but no cultural 'place' in terms of identifiers as to how to behave in another culture. To gain a full sense of cultural presence and hermeneutic richness we need to experience culture itself as a process rather than as a product.

4.8 Useful Cultural Presence

Why do we need to worry about cultural presence? Addressing the issue of cultural presence is to determine what makes the experiencing of a virtual environment meaningful, and, by extension, more engaging. Virtual reality research has been concerned with the usability offered rather than usefulness. Yet games, arguably the most successful virtual environments, also add tasks, goals, user-personification and social status for successful task performance but they do not aim for useability, they aim for provocation, stimulation and challenge:

Finally, **entertainment applications** and some educational interfaces can benefit from the fun and engaging nature of 3D, as evidenced by countless shoot-them-up games. Note that 3D works for games because the user does not want to accomplish any goals beyond being entertained. It would be trivial to design a better interface than *DOOM* if the goal was to kill the bad guys as quickly as possible: give me a 2D map of the area with icons for enemy troops and let me drop bombs on them by clicking the icons. Presto: *game over* in a few seconds and the good guys win every time. That's the design you want if you are the Pentagon, but it makes for a boring game. (Nielsen, 1998, his emphasis).

In order for virtual technology to gain widespread acceptance, we also need to evaluate the usefulness of virtual environments. For cultural environments, that means replicating reproducing or evoking cultural responses. For example, Riva et al (2002), suggested that reality is not the only component of experiencing the real world, and therefore non-real experiences should be included in virtual environments. They suggest cultural presence involves a "cultural framework" and "the possibility of negotiation" (Riva et al, 2002, p. 307). For them this must include recognition that the experience is mediated by digital technology, that it recognizes the social context, and that it allows for ambiguity.

Virtual communities thus require a stage for social events, social beings, and props that can be modified shared and created to express these social interactions and beliefs. This also appears to be the view of Kalay and Marx (2003).

A virtual environment with socially active cultural presence is a stage for presenting

ambiguous social roles and allusive cues (symbols) that allow participants to identify themselves and each other via communication and cooperation. Hence, while a virtual environment can have a sense of social presence, to have a dynamic sense of cultural presence, we need to have a sharable way of expressing socially understandable beliefs and behaviour (active cultural presence).

For Weckström (2004, p.21), in order to achieve 'worldliness', a virtual environment must also allow for various ways of doing things:

The worldliness of "the Roman world" is in the multitude of different characters involved in making it a world. For this Roman world to be rendered virtually, it should offer the user the possibility to choose from a multitude of things to do, and lives to lead.

Weckström seems to be arguing both that a world should be specific, and it should allow you to do different things in different ways. He may mean that 'worldliness' consists of three components:

- The virtual environment offers at least one thematic cultural way of looking at things (for example, being a Roman).
- There is more than one way of interacting with the world (you can invade countries, build roads, or deliver speeches to the senate).
- The way of interacting with the virtual environment depends on your selection of a certain social role (although you can select different actions this depends on whether you are a Roman centurion, engineer, or senator).

His idea of 'worldliness' may also mean that there should actually be at least two thematic cultural ways available in the world, i.e. a Roman way, and a Barbarian way. In other words, the social and cultural framework is defined not just by how it allows people to communicate, but also by the existence of a distinguishing framework.

However, while some writers on virtual place, such as Kalay and Marx (2003), argue that cultural immersion requires the perceived presence of other real social beings, we do not have contextually based evaluation data on how embedded and culturally constrained visitors to a virtual heritage site need to be.

For example, if we use our own language to communicate we will not be fully embedded in the recreated culture. Other visitors will almost certainly distract from the contextually situated embedded and embodied cultural experience.

There is however, another level of cultural presence. If the virtual environment contains a collection of artefacts that can be observed, interpreted, or understood as a coherent materialization by intelligent beings of a shared social system, this

may be considered passive cultural presence. We can see culture, but we either cannot participate in it or with it due to a lack of culturally constrained creative understanding, or because the originators have long since passed away.

Culture arises over time because people put their perception of their culture into everything they say or make. This means that outsiders can sense the culture of a place even when there are only objects present, but no people. This is usually done in archaeology where researchers try to interpret the symbolic meaning of objects that are left behind from ancient cultures. (Weckström, 2004, p. 26).

There may also be more than one group of originators. A virtual environment can thus be a palimpsest ("products of action"), where past social interactions are layered echoed and carved into the fabric of the environment. In other words, a virtual heritage environment that allows us to breathe in the past. The premise that visitors require other real people in the virtual environment in order to feel cultural presence is thus unsubstantiated and highly problematic. Cultural presence, albeit in a weakened form, is possible in the absence of social presence.

In academic literature, one can find use of the term 'aura' in a way that suggests a definition of cultural presence. For example, MacIntyre et al (2004, p.1) defined aura as a description of "...the cultural and personal significance that a place (or object) holds for an individual."

However, cultural presence as it has been used here is a more specialised notion than that of 'aura'; cultural presence creates the feeling that a place or object also contains significance for a society.

4.9 Summary of Cultural Presence Theory

People intending to travel to a heritage site may have different requirements to people just exploring a virtual world. People may want to use virtual technology in different ways; to use the information as a travel guide, to imagine explore or understand the past, or to meet and socially participate with other people. Virtual environments that would be helped by a sense of cultural presence could be virtual communities, virtual travel and tourism sites, or virtual heritage sites.

Experiencing cultural presence is an important issue not just for virtual heritage environments, but also in varying ways for virtual travel and tourism sites, and for virtual communities. Merely experiencing social presence is ephemeral and fleeting, and does not layer the environment with a felt 'history'.

Culture is more the deliberate material embodiment of social values; it has a sense of permanence that attempts to outlive its immediate originators. Either cultural

presence requires the sense of layered interaction history of culturally constrained agents, or it requires full social interaction with other social agents via interactive media. Thus we need to distinguish between shared social presence and (active or passive) cultural presence (Table 6).

Table 6: Types of Virtual Presence

Shared Social Presence	Dominant and shared cultural perspective	Passive Other-Cultural Presence	Active-Other-Cultural Presence
We notice other people in the environment.	We turn on the television, write a letter, say hello to the next-door neighbour, without really noticing what we are doing or that we are acting and behaving in a certain way.	Passive-we develop a sense of a long ago and distinctly 'alien' culture once inhabiting the site that we are visiting. There are 'traces' of past inhabitation.	Active-we feel surrounded by a people and their cultural perspective that is very different to our own. The place is 'alive' and inhabited.

If we allowed participants to appear in avatar form as typical tourists, and to chat about whatever they liked in an online world, this social presence of like-minded others may destroy the cultural immersion necessary to understand the virtual environment from a historical and locally constrained perspective. If we instead give them contextually appropriate goals rather than let them wander around at will (i.e. as travellers or inhabitants rather than as tourists), and provide contextual constraints and affordances (just as some games do); this may actually increase their enjoyment, and increase their understanding.

Whether cultural presence is transmitted via reading a palimpsest or by participating on a social stage, one must keep in mind it can be perceived from the outside (etic cultural presence), or lived from the inside (emic cultural presence). Interaction is crucial in the creation of culture, and, by extension, in the understanding of culture.

Where our environment refers to a long extinct civilisation, such a bridging is perhaps impossible, unless we somehow can bring the ghosts of the culture back to life. In other words, a feeling of strong cultural presence requires being physically *embodied* (we have a body that affects and is affected by other objects and forces), socially *embedded* (there exists the presence of others to whom we feel socially bound) and culturally *inscribed* in the world (our actions leave a lasting and meaningful impression on the world).

Photo-realism has been the goal of many virtual environments designers. Can photo-realism exist in tandem with physically embodied, socially embedded and culturally inscribed virtual environments? The next chapter will discuss specific issues that may result from attempting to develop photo-realistic virtual heritage environments.

5.1 Photo-realism is not essential

A desire for realism often conflicts with a need for interpretability. Does an attempt to perfect fidelity to sources and to realism improve or hinder the cultural learning experience? Greeff and Lalioti (2001, p. 1) argued that virtual identities are needed to allow engagement in "interactive cultural experiences....People create meaning through narrative or stories....Culture influences our perspectives, values and behaviour....Many applications, such as culture, are dynamic and therefore static representations are not efficient for portraying them." The act of personal creation through interaction would however threaten realism and authenticity.

There seems to be a conflation in popular usage between the word 'virtual' meaning to have the effect of the 'real' without actually having material or form and 'virtual' as a synonym for the word 'digital'. A similar problem appears with the common use of realism: 'appears to be real' could mean, 'an object looks like something that really exists', or 'I can believe that it exists'.

Virtuality can be defined as existing or resulting in essence or effect though not in actual fact, form, or name, for example, the virtual extinction of the buffalo. It may refer to that which exists in the mind, especially as a product of the imagination (used in literary criticism of a text). In computer science, an online dictionary (<http://www.dictionary.com>, accessed 5 January 2005), also defines virtuality as that which is "created, simulated, or carried on by means of a computer or computer network, such as virtual conversations in a chatroom."

Designers may use this conflation to persuade the viewer that high-resolution images imply a high degree of archaeological certainty, when this is not the case, "...the distinctions between real and hypothetical are not simple but subtle, complex, and far-reaching... As Mr. Emele pointed out in his article, a partially known site cannot be reconstructed satisfactorily... Our reconstructions are also too clean and neat." (Eiteljorg, 1998, p. 2).

When we talk of limits applied to virtual environments we may mean that fidelity to the real world is conceptually rather than visually realistic. Realism has its uses, but so does the expanding of perception and cultural understanding. Information may

be highly selective (more appropriate to the learning curve of the audience), interaction could be metaphorical and dramatic rather than god-like (omniscient and omnipotent), or we may have deliberately reduced the cognitive loading required to complete tasks.

The cultural significance of a world heritage site, say a Neolithic cave, may be intangible, alien, and hence unreal to the tourist. Yet to a Stone Age cave dweller the marks on the wall may be more than unrealistic drawings; they may be the culturally inviolable and hence 'real' ciphers that create and sustain a cultural setting.

The recent developments of highly accurate and large-scale virtual heritage scanning technology indicate that the impedance to capturing a sense of place in digital models is not a problem with capturing realism.

Virtual environments exist with photo-realistic laser-scanned artefacts, augmented by textures scanned in from real-world materials. However the reason why such environments lack a sense of engagement and therefore lack a sense of place is too often because they lack thematic interactivity, the interactivity that has helped make computer games so popular (Laurel et al 1994; Eiteljorg 1998; Mosaker, 2001).

While visual correspondence to reality may be a great help for visualising layout and orientation of a site, our knowledge of a place is deepened by our activities as shaped by that place, and our identification with or against that place. If a feeling of presence depends on a feeling of active participation in a place, this thesis argues that a hyper-realistic spatial setting by itself does not necessarily create presence.

The philosopher Kant (1987) suggested that an over abundance of sensory data either too large to imagine, or so large it overpowered the senses, was an aspect of the sublime. Popular cyber-literature often uses this idea to conjure up infinite spaces of overwhelmingly precise detail. However, to suggest presence is attained solely by an over abundance of realistic objects (Kant's mathematical sublime) or by overpowering physical phenomena (such as in floods, and giant waterfalls, the natural sublime) alone, is to create an environment incapable of cultural inscription. For the essence of the sublime as used by popular media's portrayal of Virtual Reality is to dwarf us and make our achievements seem physically insignificant by comparison.

Advances in digital media technology hold great promise for photo-realistic and historically authentic reconstructions of heritage monuments and culturally significant places. In order to attain a degree of 'reality', computer visualisations

have focused on reducing technical limitations in order to approach visual fidelity and accurate reproduction of real and historical environments.

Yet this love of technology as progress per se may blind us to the amorphous nature of history. A computer model can imply certitude when the data it is based on is not as reliable and authentic as the environment it was meant to portray. Further, culture itself may not always be captured by exacting technology.

UNESCO seems to agree, for it has recently developed a policy on the importance of intangible heritage.

The Convention for the Safeguarding of the Intangible Cultural Heritage defines the intangible cultural heritage as the practices, representations, expressions, as well as the knowledge and skills, that communities, groups and, in some cases, individuals recognise as part of their cultural heritage....intangible cultural heritage is transmitted from generation to generation, and is constantly recreated by communities and groups, in response to their environment, their interaction with nature, and their historical conditions of existence. It provides people with a sense of identity and continuity, and its safeguarding promotes, sustains, and develops cultural diversity and human creativity. (UNESCO, 2005, para. 1).

If history is not a precise science, we may be presumptuous in attempting visual fidelity without considering what techniques and media best afford an engaging and fulfilling experience of the cultural significance of that site (Boskovic, 1997).

This chapter suggests four points of departure for testing whether fidelity is a given or a limitation in the experiencing of virtual worlds. These premises are: architecture should not be treated as a mere object; history is not set in concrete; phobic triggers motivate people; and the most educational virtual environments are not necessarily the most realistic environments.

5.2 Architecture Is No Object, Nor the World a Sensation

For Heidegger the notion of art cannot be merely the response to sensations. Heidegger argues that we hear sounds not acoustic sensations, and thus by implication all aesthetic phenomena (i.e. those sensations that the brain responds to) are actually distillations of experiences codified and responded to as the outcomes of deliberate, intentional activity.

Much closer to us than all sensations are the things themselves. We hear the door shut in the house and never hear acoustical sensations or even mere

sounds. In order to hear a bare sound we have to listen away from things, divert our ear from them, i.e., listen abstractly. (Heidegger, 1975, p. 26).

There is thus, Heidegger argued, something to the work of art, let us call it the 'thingly character', which is not encompassed or created by the perception of mere sensations.

Heidegger's argument has recently been bolstered by experiments in virtual environments. Handy, Grafton, Shroff, Ketay and Gazzaniga (2003, p. 4) have suggested that there is indeed a 'graspable' quality to certain objects in virtual environments.

Our ERP findings converge on the conclusion that graspable objects have the capacity to draw visual spatial attention to their locations, even if those objects are irrelevant to current behavioral goals.

We may further extend the argument to suggest there is an aspect of 'thingness' to our perception of our world that should be considered in designing virtual environments.

In the nineteenth century, empathy theorists viewed architecture as little more than sculptural objects that we can create associations for (Morgan, 1996, p. 321). A few years ago, the philosopher Anthony Savile attacked Richard Foster's work for the same reason: treating the essence of architecture as sculptural form (Savile, 1993). For a thing, be it a hammer or a building, is not merely a three-dimensional object floating in space. Architecture also involves interior spaces, the linking of spaces (e.g., from inner to outer and the converse), and the placing or locating, using and imagining of symbolic objects (as well as the self and other people) in space.

Schelling suggested that architecture could be viewed as clothing, which implied that rather than merely acting as a clumsy mass, architecture covers modifies and directs our imagined and real movement. We are, after all, kinetic sculpture.

"Viewers perceived the immobility of paintings in one way by moving into and out of the focal point in front of the works. They perceived that of statues in a second way, by circling statues in the round or by passive reliefs. In both cases, the viewers moved outside of the work of art. But, in architectural settings and galleries, viewers moved inside, and through the work of art, and - as gallery paintings indicate - they became kinetic components of those aggregated works, participating in the whole." (Morrison, 1988, p. 322).

Modern architecture as the embodiment of rationality and the machine is also debateable. Many architects of the nineteenth and twentieth century, including even the early modernists, used spatial illusion. For example, Mies van der Rohe

was concerned with the art of illusion, however much his supporters might talk of structural honesty. In almost every famous building by Mies, the structure was expressed, but only partially. Hidden and unexpressed supports were necessary for the external form to appear perfectly flat and freely floating, such as in the Farnsworth house and the Barcelona Pavilion (Champion, 2004b).

The canonical work of Mies, Le Corbusier, and Frank Lloyd Wright can be viewed as Apollonian pavilions but they were contrasted with the Dionysian wildness of a national park (the Barcelona Pavilion), French fields (Villa Savoye), and a waterfall (Fallingwater). Nietzsche outlined such a theory of aesthetic contrast in his doctoral thesis on the importance of aesthetic illusion (Nietzsche, 1967).

Architecture may also create the appearance of popularity through the illusion of erosion. In the famous Woodland Crematorium, Asplund sawed into the marble columns so that they would prematurely age. In his Lister courthouse he even created a buried typology; part of a hall appears to be a dugout classical colonnade, implying the modern courthouse building had been built over another building dating from antiquity.

Yet computer models do not normally incorporate these illusions and aesthetic contrasts.

5.3 Phobic Triggers and Experiential Realism

Realism is not necessarily the same as visual fidelity; it could also mean conceptual fidelity. A person might believe something exists and is 'real' even if it does not look 'realistically' like anything unknown; as long as he or she believe it may affect him or her, as we are discovering with VR used for medicine. For example, Hoffman (2004, p. 60) wrote:

Researchers are finding that some of the best applications of the software focus on therapy rather than entertainment. In essence, virtual reality can ease pain, both physical and psychological....The results have been so promising that a few hospitals are now preparing to explore the use of virtual reality as a tool for pain control. In other projects, my colleagues and I are using virtual-reality applications to help phobic patients overcome their irrational fear of spiders and to treat post-traumatic stress disorder (PTSD) in survivors of terrorist attacks.

Problems can actually arise from the depiction of too-realistic human avatars. Thompson (2004) noted:

In 1978, the Japanese roboticist Masahiro Mori noticed something interesting: The more humanlike his robots became, the more people were attracted to them, but only up to a point. If an android become *too* realistic and lifelike, suddenly

people were repelled and disgusted.

Mori (1981) called this phenomenon 'The Uncanny Valley', and it is further described and illustrated in Bryant's (2000) online article, *The Uncanny Valley, Why are monster-movie zombies so horrifying and talking animals so fascinating?*

The latest development in game engines and interfaces is further blurring the distinction between physical and cognitive presence. Robillard et al (2003, p. 473) built a virtual environment using to a game engine help people overcome phobias and noted in their discussion that:

The first goal of this study is to determine if TVEDGs [therapeutic virtual environments derived from computer games] can induce anxiety in phobic participants. The results demonstrate that despite their low cost and flexibility, TVEDGs can be phobogenic. Moreover, virtual environments derived from games can produce the mid-range levels of anxiety that are most useful in therapy.

What is most interesting to me is that the VR equipment involved does not need to be high cost, inaccessible to the public, or capable of high resolution. The phobic 'triggers' are so strong that photo-realistic digital environments, according to Jacobson (2000, para. 4), are not needed:

Virtual reality (or VR) therapy already helps many patients overcome phobias, from fear of flying to fear of spiders. Similar systems are being tested to see if they can reduce bouts of anorexia and bulimia.

Philosophers of science have argued for many centuries that what we see is filtered reality, not actual reality (Riegler, 2001; Ferko et al, 2003). So virtual environments can be used to engage, distract, or stimulate learning styles or particular phobias.

In dealing with extreme phobia cases, photo-realistic detail is not needed, significant detail is. We may extrapolate these findings to capturing the cultural perspectives of a certain society: capturing what they find evocative and important is arguably the most important aim. Photo-realism is a great aim if we wish to test the extent of technology, but it may not be the most suitable aim for content.

For example, game designers do not all vie for photo-realism.

Realism isn't about the small details or about what is and what isn't possible. Doom 3 is realistic because if it was real, then this is what the experience would be really like. (PC Power Play editor David Wildgoose, as cited by Fordham, 2004, article no longer available online).

Just as with VR phobia studies, if a game correctly stimulates a user by such methods, the participant is too busy experiencing the sensation (horror, terror, etcetera) to worry about nitpicking the quality of detail. The same article quotes

Activision manager Jeff Wong as saying 'Doom 3 gives you that sense of creeping horror and tension.'

My term for this is experiential realism. On reflection, the participant feels that they experienced the same degree and nature of experience (of feeling) as if they had been in a similar situation in the real world. Experiential realism is afforded when the experience was visceral atmospheric and evocative, *rather* than photo-realistic capture of detail and rendering.

Realism may obscure specific information (more appropriate to the learning curve of the audience). It is not necessary for metaphorical and schematic interaction. Realism has potentially misleading connotations of 'god-like' knowledge (omniscient and omnipotent), and too much detail can increase the cognitive loading of participants to the point where they have difficulty completing or being inspired to complete tasks. In such a case, there may be occasions where virtual environment designers might actually wish to limit or restrict the degree of visual fidelity, as pointed out by Eiteljorg (1998):

...the distinctions between real and hypothetical are not simple but subtle, complex, and far-reaching... As Mr. Emele pointed out in his article, a partially known site cannot be reconstructed satisfactorily... Our reconstructions are also too clean and neat.

Designers may use the common confusion between visual fidelity and historical fidelity to persuade the viewer that high-resolution images imply a high degree of archaeological certainty, when this is not the case.

5.4 History Is Not Set In Concrete

Writers have noted that culture is improvised and transformative, for social rules are not set instructions like chess (Tilley, 1999, p. 29 and p. 272). Experiencing a virtual environment may be enhanced if the social rules and cultural artefacts can be modified. However, there are two aspects to this; the social world as lived by people inside the 'world', and the perceived social world projected into the environment as seen by people outside that 'world'.

A classic example would be the archaeological dig. The reconstructed palace of Knossos on Crete is a dynamic blend of archaeological dogma and controversial projections as well as actual uncovered remains. How could we digitally recreate the many views and ideas of the Palace?

Being part of society, archaeologists are as interested in controversy and the degree of agreed upon accuracy as they are in the historical reconstruction itself

(Kensek et al, 2002). This is also a highly specific form of etic cultural transmittance. Current digital reconstructions do not in general show the process by which archaeologists reconstruct likely scenarios as to what has taken place.

When onsite, through deducing patterns of behaviour from artefacts, knowledge of other comparative cultures, and by testing changes to the landscape, anthropologists and archaeologists may develop their own 'detective knowledge' of a past culture which is not accessible to the general public via either trips to the actual site or through tourist literature. Yet this could be incorporated into virtual heritage environments (Champion, 2002).

Part of the problem with virtual heritage projects is thus semantic in nature. Historical reconstructions may be measured in terms of their fidelity, but history is not one story but a series of interpretations.

One convenient falsehood that we embrace is that scholarship is best undertaken in solitude....We will welcome the arrival of a multifaceted interpretive model, our artworks, offering numerous ways to enlighten our visitors about our artworks, rather than offer up a single point of view that has been traditionally held. (Anderson, 1997, p. 25).

Fidelity can be seen as faithfulness to obligations, duties, or observances. It may mean exact correspondence with fact or with a given quality, condition, event, or accuracy. It may also refer to the degree to which an electronic system accurately reproduces the sound or image of its input signal, (definitions from <http://www.dictionary.com>, accessed 5 January 2005).

Yet in virtual heritage projects, the fidelity is not conceptually or even physically faithful to the past. Fidelity of reproduction is often a high resolution capture of the static leftovers of the present; using scientific extrapolation of past circumstances through analysis of remaining data, or a monument based on a singular (historically situated) archaeological insight.

Virtual environments do not tend to show how the local past inhabitants modified, interacted with, and inhabited their environment through their own view of reality. Yet hermeneutics argues that we must grasp the world of the interpreter as well as the world of the interpreted in order to gain the meaning of the text or object of art.

Hermeneutics has its origin in breaches in intersubjectivity. Its field of application is comprised of all those situations in which we encounter meanings that are not immediately understandable but require interpretative effort....(Linge, 1976, p. xii).

For example, the philosopher Hans-Georg Gadamer wrote that one could not

negate the temporal (and spatial) difference that separates the reader from author of the text they are reading. To be able to read the author of a past era or society as if nothing is lost in translation or from the passing of time implies that modern humans can separate any modern human being from their historical background.

Reflection cannot hold at a distance and objectify the past, for the present is always a given. Gadamer (1976, p. xiv) asserted that "To be historical....means that one is not absorbed into self-knowledge."

Recent research has also indicated that realistic but non-interactive installations of virtual heritage projects may bore the audience (Mosaker, 2001). Allowing participants to talk to each other in a virtual heritage world may improve the sense of engagement, but at a cost to cultural presence.

A further issue with realism is whether computer simulations can convey archaeological disagreements and alternative viewpoints. How do we present scientific uncertainty? Can we convey historical interpretation, hunches or imagined reconstructions in virtual environments?

For example, archaeologists have already developed interactive games to train students to make educated guesses. ArcDig is a two-dimensional game that allows students to guess where things are buried, and then dig for them. It then provides answers as to where and why by professional archaeologists. Such a theme could be extended into a genuine three-dimensional game that explores the probable validity, the professional controversy and the eventual outcome of archaeologists' hunches.

5.5 Summary of the Usefulness of Photo-Realism

Recommendations for designing a VR-experience are at the outset that 'augmented reality' should better be 'augmented fiction,' not so much by increasing the number and quality of realistic features but by increasing the relevance of a situation, providing features that tune in to the goals and concerns of the user...(Hoorn et al, 2003, p. 25).

The cultural significance of a world heritage site, say a Neolithic cave, may be intangible, alien, and hence appear unreal to the tourist. We may well agree that computer generated worlds and images are (ironically) limited by their lack of limitations (by views that seem to last until infinity). Yet a focus on visual fidelity rather than on atmosphere is not always a necessary or desirable component of either virtual heritage or digital architecture.

For virtual environments, limitations may be desirable rather than unavoidable. In

his essay, 'Liquid Architectures in Cyberspace' Novak (1991, pp. 225-254) defined the essence of virtual reality as freedom. Physically embodying and socially embedding a visitor in a virtual world may seem at first more confining than the liquid freedom proposed over a decade ago, but it may actually improve the user experience rather than detract from it.

Via advances in virtual simulation technology, we are now able to create online interactive worlds that also communicate a perceptual sense of light, space and time, the evanescent, diaphanous, inter-spatial and eroded features of architecture. If they had appropriate interactive tools at their disposal, virtual travellers will not just feel far more 'embodied' but also culturally immersed and socially 'embedded'. Then they will be able to gain a far greater idea of the 'horizon' of the original inhabitants. The next chapter discusses how studying the features, genres and learning style of computer games may help a visitor to a virtual heritage environment perceive contextual embodiment and a feeling of cultural presence, as well as socially embed them into such a shared 'horizon' of cultural understanding.

6.1 Game-style Interaction

6.1.1 Defining Games

A considerable amount of literature has argued that interactive engagement in a computer medium is best demonstrated by games (Schroeder, 1996; Prensky, 2001; Laird, 2001; Champion, 2003a; Manninen, 2004; Aldrich, 2004). With this in mind, this chapter suggests certain techniques that virtual environments (especially cultural heritage ones) can learn from game design.

In order to understand what computer game design and interaction could offer to people who build virtual environments for tourism, heritage, and archaeology, we need to define the features and criteria of successful games and game-style interactivity.

One of the more concise reviews of game definitions is a paper by Juul (2003, para. 15). He offered the following definition of games, which is really more the listing of six criteria for a game to be a game.

A game is a rule-based formal system with a variable and quantifiable outcome, where different outcomes are assigned different values, the player exerts effort in order to influence the outcome, the player feels attached to the outcome, and the consequences of the activity are optional and negotiable.

Juul believes these criteria are necessary and sufficient, and that only games have all six criteria. The criteria may well be sufficient, for they are certainly more comprehensive than earlier definitions, but it is arguable that they are all necessary.

For this thesis, such a comprehensive definition is not necessary. This research is more interested in what it is about game environments that make them engaging, which is not the same as attempting to uncover the uniquely identifying features of games that no other activity, product, or process shares with them.

Part of the attraction of games is certainly due to their interactive and engaging nature:

An interactive and entertaining source of play, sometimes used to learn a lesson. (Aldrich, 2004, p. 240).

More helpful for designers is the definition by Salen and Zimmerman (2003, p. 572), as it attempts to explain what makes games entertaining. In their large tome on game design, they wrote the following often-quoted definition of a game:

A game is a system in which players engage in an artificial conflict, defined by rules, that results in a quantifiable outcome.

While Salen and Zimmerman talk of a magic circle that separates (but not always clearly) the boundaries of a game from the real world, they seem to focus rather quickly on conflict (rather than the more generic terms of challenge and competition). They also discount games that may never have a final outcome (such as cricket), and do not mention the importance of strategy.

Here is a working definition of a computer game (different to Salen and Zimmerman); a game is a challenge that offers up the possibility of temporary or permanent tactical resolution without harmful outcomes to the real world situation of the participant.

6.1.2 Defining Game-style Interaction

Mention of task or strategy is important; games typically challenge and develop procedural learning through the selection of various options with varying consequences. One common feature of successful games is that they may offer different strategies of accomplishing a goal: interaction often involves hybrid-learning practices.

In other words, clues, goals, and methods are often learnt, developed, or found via conversation, observation, by trial and error, or even a blend of some or all of these ways of learning. Therefore, games offer different ways of interacting in order to learn. However, since computer games are generally goal-based, they tend to emphasise procedural rather than prescriptive knowledge. That is, they provide clues and methods for learning how to solve a task rather than teach what is right or wrong, or what is true or false.

Computer games are hence orientated towards trial and error interaction. So when I talk of game-style interaction it could be understood to mean interaction geared towards solving a task (procedural interaction), or it could be understood to mean game genre interaction (the interaction you typically find in certain types or genres of games).

Another option could be to define game-style interaction as meaning the types of interface technology (such as joysticks, and consoles) that one finds in games. Console gamers have access to task-specific devices and interfaces not common to desktop personal computers.

However, these interface devices are either highly dedicated to a certain type of game, or different in degree rather than in kind to the standard PC interface. They may well have improved task-efficiency or ergonomics, but for many games, one can still use a keyboard and mouse. Hence, the success of games cannot be directly related to the use of dedicated gaming interface devices.

Since I am attempting to increase engagement in virtual environments in order to increase cultural learning, I intend using the phrase game-style interaction to describe interaction that uses the interactive elements commonly found in games (to be elucidated in the next chapter).

6.2 Useful Features of Games

Games have context (user-based tasks), navigation reminders, inventories, records of interaction history (i.e. damage to surroundings), and social agency. Engaging virtual environments also require interaction geared towards a task, a goal. As noted by Amory (2003, p. 714):

The development of a number of models to explore the relationships between educational theory and game design provides developers with a conceptual and practical framework that can support the development process. Also, well-crafted games appear to require appropriate puzzles integrated into strong story lines where graphics, sounds and technology are used to create an entertainment medium that could also champion learning objectives.

As in games, virtual environment users may prefer personalization. Further, just as the most popular games (excluding Tetris), require representations of opponents (social agents), so too do virtual environments. Games provide competition, and therefore challenge, a feature typically lacking in virtual environments.

Games are a familiar medium to users, and help train us how to learn and how to use props as cultural tools.

Making content appealing to the end-learner may be the lesson that the e-learning industry needs to learn most of all... (Aldrich, 2004, p. 7).

As users become engaged in the tasks, it is easier to observe them without damaging their level of engagement, especially as games traditionally have built-in evaluation mechanisms. Furthermore, games cater to learning curves of new users by advancing in complexity over time, and can be personalised.

The technological limitations of internet-available virtual environments do not seem to have hindered the popularity of complex games. The most popular form of virtual environments is arguably the computer game. Nearly seventy five per cent

of people under the age of thirty have played a computer game. Entertainment software is the fastest growing of all types of entertainment, outselling films, according to a paper by Bryce and Rutter (2001, para. 1).

It is estimated that almost three quarters of people under thirty have played a computer game, and the leisure software industry is estimated to be worth more than \$6 billion in Europe making it a more lucrative market than [in] either the USA or Japan. In the USA, sales of games now outnumber sales of books and in the UK games are worth 80% more than video rentals. In the UK – which makes up more than half the European market – gaming software is not just significant in terms of consumption, as it also has an impressive development and export profile massively outperforming film and television.

Computer games are at least partially responsible for the giant leaps forward in computer graphics technology and related hardware, such as CD-ROMs (refer Laird and Van Lent, 2000; Laird, 2001; and Weckström, 2004). Laird (2001, p. 70) compared the power of these game engines:

... the original Playstation, released in 1995, renders 300,000 polygons per second, while Sega's Dreamcast, released in 1999, renders 3 million polygons per second. The Playstation 2 sets the current standard, rendering 66 million polygons per second, while projections indicate the Xbox will render more than 100 million polygons per second. Thus, the images on today's \$300 game consoles rival or surpass those available on the previous decade's \$50,000 computers.

In terms of computing power, current game consoles also rival supercomputers of a decade or more, and they are used for AI research. Laird (2001, p. 70) noted:

The impact of these improvements is evident in the complexity and realism of the environments underlying today's games, from detailed indoor rooms and corridors to vast outdoor landscapes. These games populate the environments with both human and computer controlled characters, making them a rich laboratory for artificial intelligence research into developing intelligent and social autonomous agents.

Indeed, computer games offer a fitting subject for serious academic study, undergraduate education, and graduate student and faculty research...

Via computer games, we can further explore cognitive issues of memory recall, engagement, and the notion of 'flow'. For example, according to Bryce and Rutter (2001, para. 9-11):

Psychological presence in public gaming arenas is investigated by the use of the optimal experience or the flow framework (e.g., Csikszentmihalyi, 1975)...

These **aspects of the flow experience are intense involvement, clarity of goals and feedback, lack of self-consciousness, a balance between the**

challenge of the situation and the skills required to meet them, and a feeling of total control over the activity. Preliminary research suggests that the psychological experience of gaming is consistent with the dimensions of the flow experience as outlined by Csikszentmihalyi. [Bold from original text].

Games are already being used in academic research, especially for Artificial Intelligence research. Laird and Van Lent (2000, p. 1177) noted:

One attractive aspect of working in computer games is that there is no need to attempt a "Manhattan Project" approach with a monolithic project that attempts to create human-level intelligence all at once. Computer games provide an environment for continual, steady advancement and a series of increasingly difficult challenges. Just as computers have inexorably gotten faster, computer game environments are becoming more and more realistic worlds, requiring more and more complex behavior from their characters. Now is the time for AI researchers to jump in and ride the wave of computer games.

Further, games are an important if not essential part of human culture and cultural learning. If a virtual heritage environment is to aim for at least some degree of overview of a distinct cultural perspective, it must deal with at least the representation of how that culture uses the idea of play, and the idea of games. For example, W. Holmes wrote the following in 1907, quoted by Juul (2001b, para. 2):

The popular notion that games....are trivial in nature and of no particular significance as a subject of research soon gave way, under the well-conducted studies of Mr. Culin, to an adequate appreciation of their importance as an integral part of human culture.

6.2.1 Case Study: Heretic II

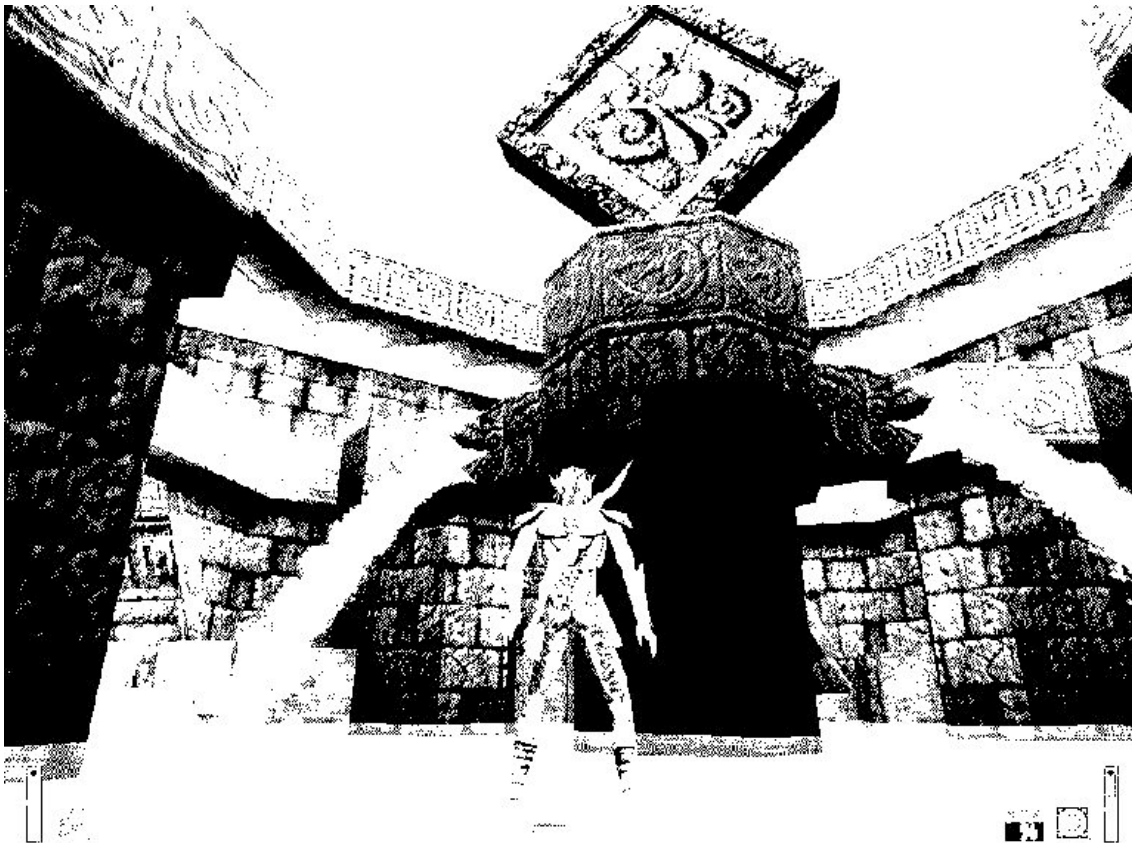


Figure 3: Heretic II screenshot

Games are activity-based rather than hermeneutic environments. To give an example of the limited hermeneutic capacity of games, let us examine the computer adventure game Heretic II (Figure 3).

Heretic II may appear analogous in form to virtual heritage environments, only it has added tasks, goals, and interactive features. In the game, the returning hero finds his town deserted except for the diseased and crazed survivors. His goal is to find the source of the virus and hence its cure.

Unfortunately, battling to escape the town he himself is infected. Time is now running out, and every so often, he too faints (often at the worst possible moment). He must explore various palaces and towns belonging to different races, identify doors, levers and portals in order to go further, gain more powerful weapons and other artefacts, find power-ups (metaphorical devices placed in the environment that boost the avatar's health and combat ability), and survive being attacked by various creatures with various diverse weapons and abilities (Figure 3).

The terrain can be outdoors or urban, and he must avoid bursts of flames, outdoor spaces (vultures will swoop on him), remaining in one place too long (creatures will start tracking him), swamp, lava, and staying underwater too long. Using Fencott's

terminology (Fencott, 1999, 2000), Heretic II contains attractors (phototropia and glints of light, prospect of open spaces), repellers (a variety of alien creatures that guard 'power ups' and lurk near narrow passageways), and connectors (such as ropes and water portals and crates you can use as steps).

The sureties are the creatures that attack, power ups, water, land, lava. The many different types of combatants have special skills, weaknesses and proclivities. If left alone, they may also fight amongst themselves. Constraints include starting the game with only two weapons, the player's avatar faints at inopportune moments, every so often users have to follow certain paths, and so on. Affordances are the ropes, weapons, power-ups, levers tools buttons ledges rubble (closed doors) and sliding doors.

In our terms, Heretic II has dynamically attenuating physiological zones that record interaction history (via corpses and damaged walls that reveal he has passed this way before). Heretic II is based on artefact-related tasks to help direct the main character to the overall goal, and a mostly static two-dimensional map (though it indicates the player's position on the map). It also has avatar dialogue (though not in the interactive single player role).

Despite the rich detailing of environments, agents, and artefacts, Heretic II does not have a rich sense of cultural immersion for the same reasons as other mainstream computer games. The only goal is collecting artefacts for the vanquishing of others, social interaction is limited to violence, time spent on reflection is punished, and we do not develop any feeling for the perspectives of the local inhabitants as their actions are purely for fight or flight.

In short, the computer game gives us examples of interactive game elements, dynamic places, agency, artefacts, and an intertwined system of goals strategies and tasks. The user is to some extent embodied as a mortal object, and has been given a social identity through the introduction and through cut-scenes.

6.2.2 Engaging Features of Games

Table 7: Engaging Features of Games

Game Features	Game Genres	Games test	Elements	Game Feedback
Physically Embodied	Combat games (usually involving aiming and moving), racing games (all usually have an element of social agency).	Hand eye co-ordination.	An avatar to represent the player, dynamic environmental elements that are hostile or beneficial, metaphorical mortality or health.	Collision causes sound, surface erosion of deformation, loss of points, end of game or level of game.
Socially Embedded	Racing games (against others-also involves some form of embodiment). Strategy games, Civilization-type world building games, interrogation or text-guessing games, riddles.	Memory (spatial, procedural, and navigational).	Set roles procedures or levels of ability to complete tasks. Other players or scripted agents.	Point system or Change status or power or equipment levels inside a game or (rarely) impostors are uncovered. There may be automated voiceovers on success or failure at completing tasks. Success may be compared to the success of other players.
Challenging (Hard fun)	All game genres.	Pattern matching and puzzle solving. Predictive thinking and bluffing.	Tasks, affordances, and constraints. Random events or options between players to vary strategies.	Increasing complexity, number of puzzles, or situations to overcome. Sometimes winning guesses or strategies increase equipment or status, sometimes more of the environment is uncovered. Can be time-based.
Rewarding	Rewards may be internal (Game Feedback), or external (awards and status conferred by other members of the gaming community).			
Hermeneutic	Unlike games and game situations in real life, where playing may be changed due to in-game events, or referential (refers to past players), this aspect is typically faked in computer games. For example, instructions are often delivered via a narrator or book during the introduction, they cannot be added to, layered, or otherwise modified.			

Table 7 classifies the critical engaging features of games. The column in grey indicates that it is difficult to separate game genres in terms of whether they involve the participant being socially embedded or physically embodied (for another taxonomy refer Crawford, 1982; Salen and Zimmerman, 2003).

However, what the table does indicate is that challenge and rewards are integral to most games but that the notion of hermeneutic inscription and interpretation is 'faked'. There is no hermeneutic richness either in the sense of being afforded rich interpretations of cultural frameworks, or in the sense that one can express oneself symbolically through the creative modification and personalisation of artefacts.

The mixture of affordances and constraints and different levels is designed to be challenging in the sense of 'hard fun'. It has to be difficult enough to be intriguing, but not too difficult to make the user give up in frustration. In addition, there are many rewards, new weapons, changes in levels, and revealed secrets. However, the game can hardly be considered hermeneutic, for the only way the worlds can be layered with anything approaching personalisation and communication is through destruction and debris caused by the user's battles and vandalism.

6.3 Game-based Learning

In the accompanying table (Table 8), we can see that Instruction, Observation, and Trial and Error as modes of learning are often found in games. However, the grey indicates that it is difficult to classify games according to the schematic modes of cultural learning, for cultural learning, itself often is a hybrid mixture of learning modes. Further, games frequently blend these modes, as can be seen in the right-hand column of Table 8.

On the other hand, it is possible to classify game devices (to create challenge or provide information) according to these cultural learning modes. The events used to tell stories (cut-scenes, voiceovers etcetera) are typically not part of the gaming itself, but are devices to provide a background. So they may possibly be used in virtual environments to recount historical events. However, they are not directly useful to virtual travel environments that cater for different modes of learning.

Travellers and tourists learn about places by going there, observing events, and being instructed by signs, guides and printed material. Such learning in games is typically before the start of the actual game, in the form of a textual introduction or voice-over. It is seldom part of the overall gameplay itself. Game tutorials, on the other hand, are procedural. Some games offer short walkthroughs where users may practise learning to jump, sidestep, use weapons etcetera. As contextually appropriate simulations, these games within games offer something real world tourism seldom encompasses, learning by doing.

Table 8: Interaction Learning Modes in Games

Cultural Learning	Descriptions	Game devices	Typical games
Instruction	We can learn about the significance of a place by social learning (by people telling you or instructing you).	Cut-scenes, non-playing characters (NPC), notes found in the scene, the intro, and voice-overs.	Being told what to do is anathema to gamers, as they typically want to act rather than to listen. Perhaps the most effective form of instruction in games is the interactive fiction.
Observation	We can deduce cultural beliefs by inference from the properties of related artefacts (for example, properties in Japan near burial grounds are significantly cheaper than other housing areas). We can also learn about the significance of a place by how old or worn it appears.	Watching other players, reading the game tutorial.	Myst is similar to early interactive fiction but it also contains pictorial clues, so perhaps it can be called an observation game. That said, observation based learning is common to many types of games and perhaps most evident in Tetris and Space Invaders (they do not require instruction to learn how to play or the outcomes).
Trial and Error	We can learn about a place through task-based activity there (for example, we learn a swimming pool is suitable for swimming).	Configurative challenges, puzzles, emergent behaviour, randomly set selection triggers.	Strategy games like <i>Civilization</i> .
Hybrid (mix of above)	We often learn through a mix of the above. We observe or read why or how people do things, we get some advice on what we are doing wrong or we overhear how or why other people do it, then we try out different strategies in order to most enjoy it, or most successfully complete the task.	(Hybrid mix of above).	Even simplistic 3D shooter games often involve instruction (at start), observation (where enemies or affordances are), and trial and error (learning how and when to use weapons).

6.3.1 Procedural versus Prescriptive Learning

There is another important distinction between real world tourism and computer gaming. In the game world, we might read erosion and damage to detect whether we have been there before, but generally, we are meant to read place features in games in order to gauge where affordances and constraints are most likely to be located. To paraphrase Adams (2004), place features in games are designed to afford rather than entertain. It might depict a mood through genre conventions, (such as specific lighting, sound, scale and symbolic details), but place is a stage on

Game-Style Interaction

which things are meant to happen in the present or indicate what will happen in the immediate future, not tell the stories of the past. These devices set the scene, rather than provide historically accurate information.

Table 9: Procedural Learning via Social Roles

Participant	Objective	Learning About An Extant Culture	Learning About A Past Culture	Game Genre
Adventurer	Reach objective by 'reading' site without embodiment being threatened.	Typically shallow hybrid of three types of cultural learning.	More observation, as well as trial and error.	The <i>Qin</i> or <i>China</i> game: escape the Forbidden City by solving puzzles. Or a 3D adventure game, <i>Heretic II</i> .
Invader-God like figure	Control or overcome inhabitants.	Mix of observation and trial and error.		Typical 3D first person shooters, <i>Black and White</i> has god-like figure.
Inhabitant (non combative)	Avoid being killed.	(Hybrid mix of above but perhaps with more strategy than observation).	Uncovering and solving puzzles in order to return to own time.	<i>Civilization</i> perhaps comes closest but it is a (isometrically viewed) game of socially constrained strategy with instruction rather than social conversation.
Inhabitant (combative)	Control or overcome invaders (this is a mirror image of Invaders profile).	(Hybrid mix of above).		<i>Civilization</i> perhaps comes closest but it is a (isometrically viewed) game of socially constrained strategy with instruction rather than social conversation.

So how does one blend game-styled interaction with virtual travel or heritage environments? Despite literature conflating narrative with environmental storytelling (Carson, 2000; Jenkins, 2004), knowledge derived from observation of place features in games is typically procedural (Table 9), rather than prescriptive (Table 10). Gamers do not learn what happened from observing features of place (shadows, openings, strange devices), they learn what to expect and where to move in case of trouble.

Likewise, in the real world, to travel through a country without outside resources we have to learn to 'read' the land, and solve local problems with local solutions. While tourists can learn from seeing how people do things, they themselves do not learn by doing but by watching the actions of others, by reading the interpretations of others, and by listening to others.

If we consider the two tables on cultural learning via social roles, it appears that travellers are closer to typical gaming roles than tourists are. Archaeologists are

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more akin to tourists, but they must actively interpret the place.

Table 10: Prescriptive Learning via Social Roles

Participant	Objective	Learning About An Extant Culture	Learning About A Past Culture	Game Genre
Tourist	Aim to enjoy life of site from a safe and comfortable distance.	Exploring and shallow modes of conversation.	Instruction, shallow modes of observation.	Extant: the new travel game genre, like <i>Weekend in Capri</i> .
Traveller	Aims to complete tasks using local affordances.	Instruction, observation, and trial and error.	Observation, and trial and error.	A Past culture: The early <i>Myst</i> series.
Archaeologist	Aims to find what happened by examining material remains, geographical changes, epigraphy etcetera.		Intense observation and deduction. Some trial and error through scientific experiments.	<i>ArcDig</i> . Perhaps murder mysteries or interactive fiction comes closest.
Anthropologist	Aims to understand the beliefs roles and relationships of inhabitants and their surrounds.	Intense observation and conversation. Instruction depends on level of emic or etic immersion.		<i>Myst</i> had elements of conversation but this is not typically a 3D game. The role the gamer plays in <i>The Sims</i> may be between this and the next category.

It may pay to tailor the virtual environment to the expected social role and objectives of the user, in terms of prescriptive learning as an archaeologist (detective), tourist (non-playing character or observer), or in terms of procedural learning aimed at the traveller (adventurer).

It may also be possible to learn about a virtual heritage environment as an inhabitant, but this suggests new game genres, for in games inhabitants tend to actually be displaced travellers suffering from amnesia (i.e. a hybrid of the social roles discussed). Traders may also be seen to be a hybrid of inhabitant, strategist, and adventurer.

When considering learning in relation to the particular social role and identity of the gamer, this schism becomes more apparent. There exists a degree of separation between games that develop procedural knowledge (Table 9), and virtual environments' tendency to follow traditional pedagogy by presenting prescriptive knowledge (Table 10).

As with previous tables, the grey denotes the least clear separations, learning about different cultures usually involves a blend of instruction, observation, and

trial and error. The separation of certain roles may be open to conjecture, for example, travellers and anthropologists both require some degree of prescriptive (historical) knowledge. These roles may be distinguished by the degree of emphasis placed on learning modes by these different social roles and identities. Generally, then, it appears that the roles and identities mentioned may be separated into those that learn by actively doing (by trial and error) and those that learn passively, by observing and by being instructed.

To separate tourist from travellers, the latter may be seen as akin to the adventurers-explorers found in computer games. An obvious example of this genre is the game example previously discussed, *Heretic II*. Progress in *Heretic II* is through procedural learning, knowledge learnt through trial and error. There is also as a degree of social instruction, 'as the last of your race, you need to do x', and a degree of observation, 'a key! There must be a lock nearby that I need to open...' but the learning in the game itself is generally through doing.

However, archaeology is usually attempting to uncover prescriptive knowledge, knowledge of events, what happened when, and who did what. Hence we could crudely separate games into those that attempt to unravel narrative (such as *Myst* and other types of interactive fiction), and those that allow interaction through doing (the competitive adventurer-explorer games). The former detective style games are much closer in spirit to the learning found in archaeology, while contextual travel (rather than commercial luxury tourism) is much closer to adventuring.

The strategist type games, where one tries to develop empires through selecting resources (and sometimes throwing dice), may be a blend of the above, as it incorporates procedural learning (via calculated risk taking), and prescriptive learning (by the game providing historical facts about the resources that may help player decisions). This type of game may expose the workings of previous civilisations, and it may incorporate historical events in the way it works out permutations of player decisions, but as a learning platform, it encounters the problem of how to separate fact from fiction for the player (Squire and Barab, 2004; Kirriemuir and McFarlane, 2003).

Having said historical learning tends towards prescriptive and not the procedural knowledge emphasised in games, one might wonder if game-style interaction would not be of use in understanding other cultures. It appears games are often competitive and destructive, focused on doing and changing rather than understanding, recovering and preserving. The next section suggests possible solutions that are not necessarily competitive or destructive.

6.4 Game Genres and Cultural Learning

As well as providing a genre for affordances in virtual environments, game-style interaction may also offer some insight into cultural beliefs and behaviours (Champion, 2004a). Four examples of game-style interaction are described here, all involve procedural knowledge, with the last few particularly oriented towards understanding the contextual constraints, social identities and behaviours of the inhabitants.

6.4.1 Snakes And Ladders

The classic snake and ladders metaphor can be applied to travel across time and space. In the case of Mayan archaeology, the inhabitants actually believed in portals that led to a sky world above, and to an underworld controlled by a lord of death. These portals were either sky-snakes or wells and cracks in the earth. Designers could use these metaphors to allow people to teleport across time and space.

In many rendering engines, collisions are captured, and avatars have some degree of physics (collision, inertia). Borrowing from the 'Steal the Flag' games, different players with different characters (and hence different capabilities) could gain points or important items by sneaking up and colliding with others.

6.4.2 Different Perspectives per Player

In some game rendering engines available online, it is possible to be in one version of an environment while seeing a player in the same world even if they are at a different computer looking at a different version of the same world. While it may not immediately appear useful, by synchronizing the players and not the world an interesting scenario can be developed.

Each player can see each other but each player is trapped in their own perspectival version of the world (Figure 4, museum modelled by <http://www.planetavivo.org>). Only through other players describing their world to them can invisible (unsynchronised) objects appear to the players.

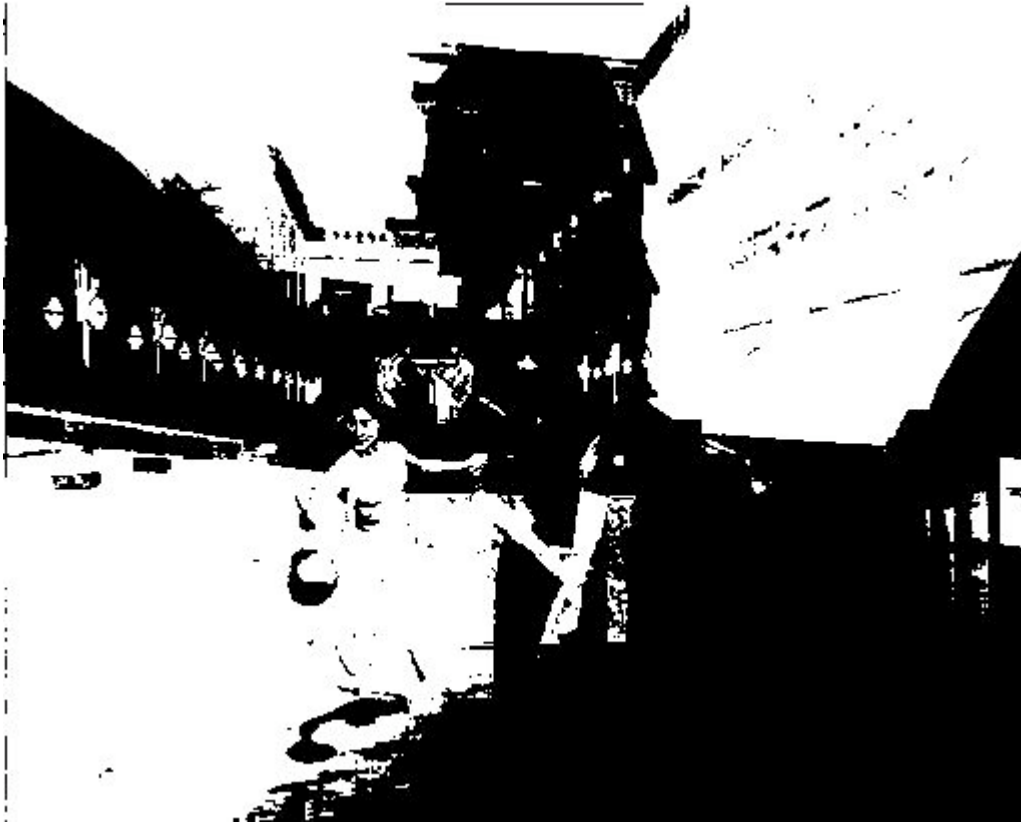


Figure 4: Shared Avatars with Personal Worlds

A simpler version of this game would be for players to have avatars invisible to themselves. In order to find out their social role, where they fit in and what they can do, it may be necessary for them to encounter other players in order to have their physical form described to them.

6.4.3 Role Playing

Perhaps the most powerful way of historical immersion is via role-playing. Although theatre provides a strong metaphor library for virtual environments, improvised theatre is more apt as it requires direct audience interaction while having some plot guidelines. Participants could 'wake up' in social roles and social costumes, and have to gain information from local avatars as to what they look like, who they are, and their role and abilities in that culture.

Many traditions tell of changelings. Players could learn different ways of interacting with the world depending on the nature of their character's background and the location of that character. In the case of Mayan culture, everyone had spirits that wandered the world at night and fought battles with evil spirits from the bowels of the earth.

6.4.4 The Spy Game

Perhaps the most interesting and most promising metaphor in terms of cultural

immersion would be that of the spy game. In this scenario, both scripted agents and players are given characters and agendas. Other agents or players are given the task of trying to find out who are the real inhabitants and who are the pretenders through the choice of words, how suspicious their movements or behaviours, or by how long they tarry in a spot without doing what they are supposed to do.

6.5 Interaction versus Historical Authenticity

We can avoid artefacts solely designed for conflict and destruction when we design virtual environments with cultural presence. Yet another factor that might conflict with interaction, and records of interaction history, is that (virtual) tourists traditionally look for authenticity. Paradoxically this means a desire for an environment that is both authentic (untouched by crowds of tourists and tourist related industry), and amenable to tourism (replete with contemporary tourist resources and facilities).

Perhaps most importantly, if the virtual environment shows changes over time (something multimedia is brilliant for), historical accuracy needs to be aimed for, for educational reasons, but people also want autonomy. Virtual tourists want an opportunity to interact with history and to chose interpretations of the past, but as we advance in time towards the present the more factual the account of what happened, the less the opportunity for autonomy. Juul (2001a: Conclusion, para. 1) wrote:

There is an inherent conflict between the *now* of the interaction and the *past* or "*prior*" of the narrative. You can't have narration and interactivity at the same time; there is no such thing as a continuously interactive story.

We could examine historical games such as Close Combat or Civilization for ideas on how tourists could interact more meaningfully and entertainingly with history. However, games that perform the role of 'game-fictions' gain their engagement not from adherence to historical events but from their ability to depart from 'the historical record' (Atkins, 2003, pp. 88-89; Jenkins, 2004).

There are at least nine possible partial or complete solutions to this issue.

6.5.1 Ancillary Non-Celebrity characters

We could create ancillary characters that are not recorded in history, and allow people to take on their roles. Given people's ability to 'augment' history with their own personal interaction history (fictions), the interactions they have with historical figures (henceforth referred to as 'celebrities'), could enhance or embellish the

personality of the celebrities.

If the artificial intelligence deployed was highly sophisticated, the celebrity could remember past interactions, and get bored with routine actions of the ancillary characters, forcing the non-celebrities to attempt ever less likely interactions.

6.5.2 Autonomous Action, Immutable Results

We could allow participants a myriad of actions, as long as their actions achieved the right results (construct Stonehenge, invade Britain, take coffee beans from Arabia to Java, etcetera). However, they have to take these coffee beans at the right time and to the right place.

A theory buzzing through the social sciences, memetics, talks of certain 'killer' ideas that takes on a life of their own, using people as carriers rather than as the progenitors. A meme is a popular self-serving cultural concept with no single owner, a cognitive equivalent to Dawkin's description of the 'selfish gene'.

Robert Aunger describes Memes in his edited reader, *The Status of Memetics as a Science* (Aunger, 2000). They are from a theory postulated by Richard Dawkins in his book *The Selfish Gene* (Dawkins, 1976). This sort of option could simulate the spread of ideas in a memetic way, independent of individual intention, but socially inescapable and inexorable.

6.5.3 Groundhog Day

In the film *Groundhog Day*, the actor Bill Murray plays a weatherman caught in a time warp, no matter his action he keeps waking up to the same morning. He eventually escapes the time warp by choosing a considerate and unselfish action for the first time in his life. In a similar fashion, a virtual heritage environment could allow participants to choose any action, but only one or a few would allow the historical plotline to move forward. Only the correct interactions would be recorded, although the number of times an actor chooses the wrong action could be counted.

6.5.4 Possible Worlds

This method would allow virtual participants interaction to change history with the result that participants find themselves in parallel possible worlds. This approach has been heavily used in science fiction (H.G. Well's 'The Time Machine', *Black Adder*, *Bill and Ted's Excellent Adventure*, *Dr Who*, *Star Trek*, the Canadian film 'Possible Worlds' etcetera). While fascinating from 'the what' if scenario point of view, this method may be less useful for teaching historical facts.

6.5.5 Diary of Emotional Development

The main narrative follows historical events but participants are given the opportunity to write down or otherwise record the emotional development and mental states of main character celebrities. Participants might also have the option of recording in multimodal form any events they think are crucial turning points.

While becoming the self-appointed scribes of history might be personally informative, participants are not likely to be highly engaged, as the interactivity is not varied and they do not contribute to the story. Perhaps the celebrities could punish those scribes who are too clumsy, forgetful, or inaccurate. The scribes' stories could be embedded into the virtual environment, and be commented on by other scribes.

6.5.6 Surfing Memetic Drift

Actors have to choose the successful memetic idea, social force, or artefact that changes the world in a significant way. Only if participants choose the correct object or idea can they advance through time and space. Each artefact may trigger other related events that also change history, so the actor can choose from a web of possible associations. If the actor chooses the wrong idea (for example, picks the turkey to represent the United States—it was mooted over the eagle), they might have to endure a video of what happened before being told no, it never actually happened—start again. A database could record the participants' choices against reality, and against those of previous actors.

6.5.7 Augment History with Real World

It is possible to augment history with annotations of real-world visitation. One could use social agents as guides to trails left by previous visitors who deposit into secret caches videos, sound recordings, images, or the place as they visited it in the real world. Or perhaps their clues get washed around or moved by dynamic environmental forces, and the current participants have to match the 'clues' depicting real places, to where those places are or will be in the virtual travel environment.

For example, a young woman climbs the Himalayas. In the many cyber-cafes of Kathmandu or from a PDA with GPS (a Global Positioning System), she could email audiovisuals of her path into the virtual environment, which her parents could follow from a computer in their own home. As they watch her photos, they could spin around in the related 3D context of the place she is visiting as it is now (perhaps fed by real-time climatic data) or as it used to be thousands of years ago.

6.5.8 Augmented Cultural Exchange

In a virtual environment, visitors could meet other visitors. The other visitors could be actual inhabitants of that site, academic authorities, computer generated characters, or even real people as virtual characters who deliberately give misleading accounts of the area and of themselves. The goal could be to identify who are the locals, authorities, and deceivers (agent based or human users), and what the truth actually is.

6.5.9 Reversed Time Travel

All of the above options are chronological in the typical sense, participants encounter problems, try to solve them, and travel through time as they do so in a forward motion. Yet the scientists' uncovering of the past (and hence the discovery of the content of virtual heritage environments), is looking backwards by thinking backwards. By uncovering fragments, scientists piece together what happened before and afterwards.

If participants find a germane and pivotal artefact, event or action, a portal opens and could take them to the associated past leading up to the creation of that object. Hence, the task is to find doors to the time before rather than to the time after. As people travel further back in time, less is known, and there are more potential interpretations of the era. This means that participants can interact more and more with the main narrative. Over time, the artefacts, and the records of the participants' own interaction history may become lost, turned into myth, or covered up by 'alternative' histories.

6.6 Summary of Games as Learning Platforms

Many virtual environments have aimed for realism rather than for meaningful interaction. Yet this may not be the most effective means of educating and engaging the public.

Material culture is not a collection of objects; it is an embodied and embedded snapshot of a dynamic world-view, an interface and depository to social ideas and beliefs. This interface of art and craft allows us to visualize our cultural understanding and transmit it to others for review and feedback. If culture is an interactive process of observation, instruction, and active participation, we need to know how we can meaningfully replicate this process in virtual environments. It may prove easier to evoke this world-view through vagueness and uncertainty rather than through clear and unbiased vision.

Game-Style Interaction

In order to do so, we may learn from game-style interaction. Games are challenging, rewarding, and sometimes personalisable. They also offer cues on how to help people navigate through virtual environments. The specific elements that make three-dimensional games engaging and believable rather than realistic may also be usefully applied to virtual heritage environments. However, games are typically not hermeneutic, and are based around procedural rather than prescriptive learning.

Unlike many games, virtual heritage environments also have a set narrative to tell. How do we allow the freedom of interaction and personalization along with the unveiling of history through one or more narratives? Can we infuse written history with multiple personal and cultural perspectives? This chapter suggested nine different methods of combining historical fact with game-style interaction, but there are certainly far more to be discovered.

In the next chapter, the components of games that lend themselves to increasing engagement in virtual heritage environments will be discussed in detail. From the game design elements discussed, specific research areas will be outlined in order to set up a research agenda for a prototype evaluation.

The Generic Issues chapter argued that virtual environments (especially virtual travel environments), have several challenges to overcome. These included not being very accessible, a lack of meaningful (conceptual) content or contextual interaction (and personalisation), and they typically suffer from a lack of *prescriptive* theory and criteria in developing improving and evaluating virtual environments.

Although there are many issues and themes in the design of virtual environments, this thesis has discussed four factors that may help address these generic problems. These are

- Context-related factors that help create a sensation of place (as a cultural site).
- Factors that help immerse people spatially and thematically into a cultural learning experience.
- Theoretical and hypothetical alternatives to realism in order to improve the cultural learning experience.
- Game-styled methods and scenarios to create a more engaging environment in order to improve the cultural learning experience.

I now intend to expand on useful theoretical concepts, terms and techniques, as well as overall research areas and research questions that may help us critically evaluate the success and failure of virtual environments.

7.1 Terms

In order to apply and improve virtual environments designers need to share a clear design terminology. Sharing of research and language between disciplines, such as the field studies of cultural anthropologists, environmental psychologists testing criteria of presence, and virtual environment designers, would help create virtual environments that are more meaningful and engaging.

Presence: I have previously argued that Presence as in 'being there' and when

tested as Social presence, Engagement, Negative Feelings, Spatial Presence etcetera in a virtual environment does not fully evaluate cultural presence. Hence, it is not fully suitable as it stands for testing simulations of cultural environments. Yet travellers typically travel to cultural environments, hence a virtual travel environment should address the issue of presenting cultural presence.

Presence researchers have conflated cultural presence and social presence. On the other hand, I suggest that we should distinguish between the two as below:

- Social behaviour is behaviour between two or more people.
- Cultural behaviour is a subset of social behaviour, where behaviour is governed by or understood in terms of a cultural setting involving the constrained use of artefacts.

As discussed above, I believe that appropriate context (and especially intangible content such as cultural heritage), is missing from a great deal of virtual heritage environments (Champion, 2003b). With the view to analysing cultural interactions in a virtual environment, I propose that terms used in both environmental psychology and in anthropology and archaeology would be suitable. These fields offer a scholarly framework for digital environments due to a focus on environment-people interaction, cultural behaviour (people-people interaction), and the interaction of people with their culturally defining use and creation of artefacts (people-artefacts interaction).

The terminology between information design and archaeology is similar, adding weight to the use of a related terminology, as it appears to be in some currency across disciplines. Moreover, a terminology acceptable across disciplines must surely be a requirement in the discussion of virtual environments for cultural learning.

A major part of Schiffer and Miller's theory relies on a three-way means of communication (Schiffer and Miller, 1999, p. 59); information is transmitted person to person via artefacts, not directly person-to-person ('receiver-sender') as in linguistic theories. A person modifies an artefact, which is decoded eventually by an archaeologist's 'relational knowledge'. There are thus three interactors (further described below).

The theory is also based on interactivity, allows for interaction independently of humans, and allows for quantifiable research insofar as there can be discrete (i.e., observable) interactions. Weaknesses may include an over generous definition of materiality (materiality seems to include everything), and an inability to discern mental states of participants in a virtual environment (due to its behavioural focus).

Interactors: An interactor is any object that can take part in interactions, which is in a way a circular definition (Schiffer and Miller, 1999, pp. 12-13). An interaction must arise from one or more performances by interactors (each interactor has a range of performance characteristics). There are three types of interactors: people (actors), artefacts, and externs.

People (Users): In a virtual environment, people may be visitors (travellers or tourists), or inhabitants. They may wish to loiter, to be guided, or seek out certain views or tasks. They may differ in their purpose (goal), in their preference for mythology or history, ability to navigate or solve complex tasks, and desire to personalize the environment or socialize with other avatars.

It may be necessary to evaluate the effect of interactive components on engagement in virtual environments, assess the popularity of 'travel' versus 'tourist' levels of interactivity, and weigh up the needs of 'inhabitant' and 'visitor'.

One way of describing the overall elements of a digital environment might be to borrow from performance media. Terms that could be used include the actor (the visitor to a digital environment); the backdrop (the default environment); the audience (those observing but not taking part); props (artefacts and naturally occurring objects); dialogue (in multi-user chat rooms); cues; motives; and plot devices. There may also be improvisation (as metaphors for triggered events, agent behaviours, predefined scripts, and random or actor-directed actions and events).

Schiffer and Miller (1999, p. 16) give a long list of academics in the social and behavioural sciences using the actor metaphor. Schiffer and Miller further extend the actor / performer metaphor but in reference to what they call anthropological archaeology and its attempt to re-focus on people-artefact interactions. The terminology focuses on material culture interaction, using interactor, artefacts, and externs as the basic elements.

Artefacts: "are phenomena produced, replicated, or otherwise brought wholly or partly to their present form through human means" (Schiffer and Miller, 1999, p. 12). Types of artefacts are platial ("reside in a place....include portable artifacts [artefacts] stored there."), personal artefacts (actual or temporarily associated with the human body), and situational artefacts "arrive with people or turn up at a place for the conduct of an activity" (Schiffer and Miller, 1999, pp. 21-22).

Extern: An Extern "takes in phenomena that arise independently of people, like sunlight and clouds, wild plants and animals, rocks and minerals, and landforms" (Schiffer and Miller, 1999, pp. 12-13). This is a useful term as interaction in a virtual environment seldom makes the distinction between that inherent in the environment and that triggered by a user.

Trace: Although not included in the above 3-term interaction theory, another important Schiffer and Miller term is the formal trace, properties of material that have been modified. For example, by analysing food residue left in a pot, archaeologists can infer that it was used for cooking rice.

Life history: A life history is “the specific sequence of interactions and activities that occurs during a given interactor’s existence” (Schiffer and Miller, 1999, p. 26). Sets of closely linked activities are called processes, which in turn are subsets of life histories.

The creation of a common terminology may be helped by Schiffer and Miller, but listing design goals, intended audiences, environment elements, and interactive methods used would also help focus attention on creating content, rather than mere form.

7.2 Features of Engaging Interaction

7.2.1 Embodied and Physically Responsive Places

Writers have already argued that virtual environments lack meaningful interaction, especially as compared to games. This thesis proposes that we can modify certain features of game technology to create a more interactive and hence more engaging virtual environment. Virtual places could simulate dynamic processes; representations of the users (avatars) could be physically embodied in the scene; and traces of interaction involving the avatars could be left in or even possibly modify the environment.

Cultural context requires a setting (task, place, artefact, and intention). The stage or the setting is the scene for initiation into a local perspective. Without the static and dynamic constraints of the physical world, the participant is left with few cues of how to explore and understand the virtual realm.

In order to evoke a sense of ‘dynamic place’ the virtual environment can be permanently modified by user interactions, and parts of that environment may impede the progress of the user in order for the user to recognise trails and paths, and socially accepted ways of travelling through the environment.

Real world places have changing conditions, rain, wind, heat, and so on. Rain could change the lighting or affect the ability of the visitor to navigate quickly and efficiently. The simulated glare of daylight (through bright lighting), could reduce the user’s ‘health points’ and similarly impede their journey. When visitors enter buildings, their health points could slowly return to normal.

It is possible to have various aspects of the environment dependent on real world data, connecting across the Internet. One virtual heritage project contained animated fireflies; their movement was directly dependent on real time stock market movement delivered via the Internet (Refsland, Ojika, and Berry, 2000).

Another example is the game Black and White. The climate in which the game is set is determined by real world and real time weather conditions; the player selects their location and the game downloads current weather conditions via the Internet.

Where the user (puppeteer) actually controls an avatar or a role-based character in a digital environment, there might be use for a puppeteer analogy. Where the actor is actually the puppeteer, where the avatar is the puppet, and the strings or rods are the exploratory/interactive methods, one criterion of immersion could be how fully the puppeteer begins to feel he or she is actually the puppet.

Likewise, in a virtual environment life histories of artefacts could be multimedia vignettes that are triggered by proximity or contact or by the successful completion of a task.

Traces could be cultural, activity-based, or related to the user's physical embodiment. The environment may keep a record of the user trails via footprints etcetera, or it could retain 'traces' of what the user did, or erosion caused by previous visitors or inhabitants (wear and tear, for example).

If we created a virtual archaeology environment with 'traces' we could ask visitors to act as detectives and attempt to interpret the past by extrapolating from these 'traces'. The obviousness of these 'traces' could also relate to the time spent in the environment, or to the success the user has in completing tasks.

7.2.2 Socially Embedded and Constrained

It was argued earlier (in section 3.3.4) that the significance of a place is often understood by social learning (by people telling you or instructing you), by observing rituals and behaviours of the inhabitants, or by interpreting and acting on symbolic cues or signs of inhabitation. In order to learn a culture, all three types of interactions need to have contextual constraints, where a constraint can be seen as an accepted parameter of cultural perspective. A computer game also needs challenging constraints in order to develop a sense of engagement. These constraints can help shape and inspire the user experience in solving the problem (Erickson, 1993).

Persistent engagement requires a task and an objective, not just 'aesthetic wonder' (i.e. staring at well-designed or artistic objects in appreciation of the design skill). Persistent engagement is not just immersion but immersion plus a task. There is

both conceptual engagement and sensory engagement; designers need to cater for both in a virtual travel environment if it is to be fully engaging.

In travel environments, there are issues of geography, timing, and 'cultural perspectives'. Travel potentially involves solving a task despite constraints, and further, in solving a task one has to adopt local methods and perspectives. In doing so, one changes one's mental model of the environment. Therefore, contextual interactivity is important. This adds to engagement in travelling through a foreign environment.

However, these goals do not exist by themselves. To make such goals more meaningful we should provide for social identities that can give specificity to these goals, and provide for a social framework in which these goals can be discussed. For virtual travel or even heritage environments we should consider whether we are providing for travellers, tourists, archaeologists (and related social scientists), or for inhabitants.

Travellers require more contextual interaction than tourists do, they have goals, places to see within a certain period of time and without too much exertion, people to find or to avoid, items to seek out purchase or utilise. Inhabitants are more constrained yet knowledgeable in some ways than visitors (travellers and tourists); they have certain place-related tasks to complete using local resources. Giving people goals (as travellers or inhabitants) may increase their engagement or sense of authenticity (Mosaker, 2001; for an alternative viewpoint see Hedman, 2001).

Unlike tourists and even travellers, inhabitants have certain roles, responsibilities and powers (Gee, 2004; Weckström, 2004). One problem with allowing users to take on the roles of inhabitants of a virtual heritage site is the amount of learning a person acting as a native would have to undertake in order to behave and communicate as a person with the requisite local knowledge. The design would have to allow users to begin as people with some form of amnesia or madness. Online communities with role-playing interaction may start this way, but the interaction is typically genre-based, and less hermeneutically enriched, socially constrained, or culturally specific.

7.2.3 Hermeneutic Enrichment and Historical Traces

Normally visitors in 3D worlds communicate to each other via 'chat' boxes. There may be other contextual ways of communication in and across virtual environments. Chat could be filtered so that only local words are sent between users, or there could be a translation service. Alternatively, artefacts could have text mapped onto them as images.

Researchers might like to explore the implications of user-user messaging in augmented reality environments, with users being able to leave future visitors multimedia messages and annotations, or participants being able to interrogate agents on previous encounters with other participants. It would be an interesting test of social presence if participants were challenged to identify other participants pretending to be agents.

Personalisation is another factor to be tested for its influence on engagement. Once inspired by this new cultural knowledge, people may like records of their virtual travels via downloadable 'memento' maps (records or playbacks of their virtual world travels). Perhaps real world travellers would find it useful if they could annotate these memory maps on their portable devices with their real world travel experiences.

It is possible that if actor-authors could augment the virtual environment with these real-world notes (i.e. upload notes back to the virtual environment so other people could read these travel diaries), that their and other participants' engagement would be further enhanced.

There is however a problem with freedom of interaction in a historically 'authentic' environment. Dramatically compelling games only have one meta-narrative, and are teleological; they tend to go forwards rather than backwards in time. When people choose options, they may interfere with the actual historical outcomes. We may attempt to solve the above by distinguishing 'turnkey' (or inhabitant-based) events from spontaneously chosen (visitor-based) events. Various solutions were mentioned earlier (refer section 6.5).

7.2.4 Evaluating Users via Game-Style Feedback

It is easier to improve a virtual environment when we have feedback mechanisms that tell us which parts of the design work best for the intended audience. How do we evaluate user satisfaction? For computer games, the answer is a commercial one. Successful games are bought by people who personalise game artefacts and make worlds (often called 'levels' or 'maps') to add to it. The most popular games involve worldwide online competitions to combat others. Highly detailed online fan forums also support major games. In short, audiences generally rate games by how engaging they are.

In a game, the primary goal is to survive adversity by defending or attacking, but often there is a secondary goal of working out contextually situated puzzles, and acquiring artefacts to solve tasks. It may be instructive to users if they can collect and trade artefacts in order to improve their social role. Some artefacts could act as

portals to previous times or to related environments. By relating the use of artefacts to tasks and to setting, the user may better understand the original cultural significance of the object.

7.3 Suggested Interactive Elements

7.3.1 Dynamic Places

To evaluate a virtual terrain with and without dynamic interactive features is an essential step in evaluation of place as opposed to cyberspace.

With this in mind, one could create dynamic places (GIS-enabled database that stores and records localized events and occurrences); along with visual and audio cues indicating changes in climate flora fauna and terrain. In addition, parts of the environment could be harmful to the avatar's metaphorical health.

An environment could host a gradient of inhabitability, ranging from shelter and familiar territory, to a hostile world depending on task direction, artefacts carried and preservation of health points. The more aware and adeptly the user can navigate through the environment, the quicker their journey between tasks, and the less the health points that they will have lost.

During the night or during severe simulated climatic change (indicated by the sound of strong wind etcetera), their health points may be drastically diminished and so they will be encouraged to look for shelter.

Creating dynamically changing environmental factors that have an effect on how people move through virtual environments could increase engagement and provide for experiences that are more memorable. Paths, changing light and obstacles may aid or impede navigation.

The dangers and opportunities of the environment could also be contextually related to the local cultural perspective and to the overall goal of the wayfinding. In tandem with metaphorical embodiment (i.e. a sense of mortality is symbolically represented), less skilful navigation could adversely affect metaphorical 'health points' (as borrowed from game design).

7.3.2 Constrained Tasks and Goals

A virtual environment could give people specific roles; allow them to choose roles, or allow them to move up or down the social ladder depending on how well they complete their socially defined tasks. Hence, the goal would be social progression. As Juul (2003, Conclusion, para. 3), argued:

The rules of a game add *meaning* and *enable actions* by setting up *differences* between potential moves and events.

We have seen that games provide goals and tasks, but that these are typically violent in nature (especially towards the inhabitants). However, I suggest that there are at least three non-violent learning modes used in games that we could modify to help structure goals and tasks for virtual heritage environments. Three non-violent but possibly competitive interaction modes common to games are Observing, Exploring (trial and error), Conversation (and Trade). Sterelny (2003a) wrote that modes of cultural learning are complex and usually hybrid but it may be helpful to sketch out a schematic of cultural learning through interaction (Table 11).

Table 11: Schematic of Cultural Learning

Interaction	Description
Observation	Inferred Narrative: through observing how agents or externs change in the environment, users may infer how to act or behave, or how the world is seen by the people who live there or by the designer of the world.
	Exploring: the visitor can explore static or dynamic environments without having to navigate past obstructions or having to manipulate the environment or solve tasks. Typically, explorers learn in virtual environments by navigating through the environment, approaching objects, and observing what happens via pre-scripted triggered information or pre-recorded events.
Trial and error (activity-based)	The aim is to investigate dynamic environments that involve risk or hindrance to the explorer. Typically, investigators learn by clicking on objects, or approaching objects, which may trigger information or pre-recorded events.
	Reconfiguration: may include solving puzzles by clicking on certain objects or choosing certain combinations perhaps at certain times.
	Detective work: inspired to develop and test hunches in order to solve riddles.
Conversation	Instruction: guided instruction via avatars or embedded narratives.
	Verbal pattern matching: one says or enters words for doors to open.
	Conversation: one learns by talking to others (they are either real people represented by avatars or pre-scripted agents or AI controlled agents).
	Trading: can be non-verbal but is still arguably a form of communication.

7.3.3 Social Agency: Avatars Agents and Actors

This thesis will use actors as the generic term for users / participants in an interactive virtual environment, represented by three-dimensional characters ('avatars'). Research indicates social presence is linked to a sense of interactivity. Introducing other users into a virtual environment only increases the feeling of presence when interaction with others is possible, there needs to be genuine interaction with these other actors (Schubert et al, 2000).

Wickens and Baker (1995, p. 515) suggested one of the five features of virtual environments was being 'ego-referenced', that is, from a user perspective rather

than from a fixed-world perspective. Others have argued for virtual identities and social presence (Greeff and Laloti, 2001; Schubert et al, 2000). Kelso et al (1993, p. 2) described people as 'interactors' adding to the 'dramatic presence' of social presence and interactivity factors.

Computer-scripted agents ('agents'), represented by avatars that users can talk to, gain information from, and that remember them, can give the user information on where artefacts are, and how where and when the artefacts can be used.

Many projects are now using agents (or bots) for interactive story telling in virtual environments (for example, <http://www.eg.org/events/VAST2001/> or the conversational humanoid project, at the MIT Media Lab, <http://gn.www.media.mit.edu/groups/gn/projects/humanoid/>).

Hence, computer-scripted agents could answer certain questions. They could also remember who passed by and what they did. They may have a limited ability to allow participants to leave messages for each other, which may aid social presence. Towell and Towell (1997) suggest that a sense of presence is evident even in 2D mediums, such as chat groups, because of the strong feeling of talking to other intelligent beings.

Agents can give out tasks, increase realism, and help navigation. In addition, Behr et al (2001) described an avatar that talks and moves, and acts as a guide, while visitors explore the virtual environment, but that is all (Mulholland and Collins, 2002). Pape et al (2001) also proposed creating a virtual guide for historic sites. Only none of these examples are very interactive. For example, not a single paper appears to have suggested using scripted agents as evaluation mechanisms for user engagement.

It is feasible that by using computer-scripted agents participants can gain a sense (to some degree) of social presence, awareness, and identity. The agents can also be used as navigational and task-related cues, and they can record conversation for evaluation of user engagement. For example, these agents could be capable of not only simple dialogue phrases that participants can engage with to find out information, the agents' memories of these conversations would allow us to evaluate the engagement of the participant in an environment. The agents could record the accuracy of the dialogue when people attempt to communicate with them.

The users would thus need to learn what questions could be asked. The degree of recall efficiency by agents is related to the culturally appropriateness of the dialogue. It would also be very interesting to allow agents the facility over time to have their dialogue corrupted by alien (i.e. non-contextual) phrases of the

participants.

Tasks for actors could include, discovering secrets using artefacts and agent dialogue, collect information and or artefacts of interest. At higher levels of interactivity actors can leave messages via agents for future visitors.

7.3.4 Artefacts

Once designers have provided goals for participants in virtual environments, they will need to create interactive elements to enable and encourage participants to reach those goals. Fundamentally, there are three such interactive elements, social agency, modifiable artefacts, and dynamic environments.

If social behaviour is an important way of transmitting cultural information in relation to artefacts (and externs), then what is required is some form of seemingly autonomous social agents, be they computer based or other participants (Roddy, 2000). However, participants do not just learn about social agents through viewing how they are represented, participants also learn about them through how they interact with the environment. This interaction is via the manipulation of objects, and the creation of objects to manipulate other objects. In short, artefacts represent the transformative desires of the people that wield value and exchange them.

Designers of real and virtual environments also need to build on the relationship between patterns of inhabitation and usage of spatial artefacts, such as furnishings, in order to reveal the personal taste and habits of inhabitants (Rapoport 1982; Beckmann, 1998).

Artefacts may also help represent the local physical affordances of the environment. There is a growing view that physical space and engagements need to address perceptions of appropriate or believable social behaviours (Schuemie et al, 2001), and reactive artefacts (that respond to interaction in constrained and contextual ways), may help indicate how, where and when to behave.

In a virtual environment that simulates a past culture, the ability to code and relay information through interactions with artefacts is surely as useful (if not more so) as interacting directly with computer-based agents. It is more authentic in the sense that more of our information of past people does actually come to us via inferences (which Schiffer call *correlons*), than through actual people or direct representations of people.

Meister (1998, para. 1 and 13) claimed that too often buildings are perceived of as instantaneous products. Their relation to culture is also frequently simplified:

We art historians too often speak of temples as if built by kings, but they are

built for communities; as ritual instruments the use of which changes; one function of which is to web individuals and communities into a complicated and inconsistent social fabric through time. They survive by communities making use of them in a reciprocal relationship of self-preservation quite removed from agendas of historical conservation, Osymandias-like memorialization, or archaeological concerns. ...a temple is not one structure, nor of one period or even one community. It moves through time, collecting social lightning and resources. It must be repositioned constantly to survive.

According to recent research (Mosaker, 2001), tourists want to share cultural perceptions and learn through doing, being told, observing, and asking. They wish to feel engaged in the activity, enjoy the spectacle, feel the pressure of time (the relative cultural idea of time-place), and understand the 'embedded' meaning of local cultural activity based on artefact.

I love old artefacts, particularly from really old civilizations. They're like a way of viewing the world through someone else's 5000-year-old eyes, a testament to small lives. I get the same from Outsider Art - people who've been dirt-poor manual labourers all their lives asserting that they have a mind, a way of looking at the world that's their's.

The kind of vague idea I have is about a crowded space filled with 'things' that represent people - lives - in the way the Sumerians would place worshipping figures in their temples to represent themselves praying in absentia. And the sounds would be those lives confirming their existence, the fact that they're as important as anyone else in the scheme of things! So I want to produce fairly happy sounds, not mournful wails that would sound like they're grieving over the fact that they're dead - more to evoke the kind of feeling I get when I go into the Egyptian Room in the British Museum, say. A satisfaction that these people have had a life, and that it's commemorated. (Davey, 2003. Personal communication by artist to author via email dated Thursday, May 15, 2003).

Even if the word 'culture' is a noun and not a verb, cultures are processes, not products. Cultures can only exist socially through artefacts, labelled by Sauer as 'agents of change' (Crang, 1998). However, artefacts alone constitute only a fragment of the cultural process. To understand a cultural environment, one requires both artefacts, and an idea of the task that motivates using them.

7.3.5 Digital Maps as Interactive Epistemic Artefacts

Maps are interesting artefacts, for they are often viewed as straightforward devices to locate and orientate. Yet they are not just instrumental artefacts but also epistemic ones with a long history: they have helped organise our knowledge of the world for many millennia.

Sterelny (2003b, p. 5) traced the ancestors of the map (cave paintings) back over 30 000 years:

With the invention and elaboration of pictorial representation, humans came to be makers of specialised epistemic artefacts. It is very difficult to date the first appearance of specialised epistemic artefacts, but unmistakable, superbly executed paintings are over 30,000 years old (Mithen 1998). In Mithen's view, the use and elaboration of epistemic artefacts explains the extraordinary acceleration in both the richness and the variability of human cultures over the last 50,000 years or so. He thinks our archaeological record shows the marks of a cognitive breakthrough.

Sterelny (2003b, p. 4) wrote that maps are “tools for thinking”. That means maps are epistemic artefacts, they are items that structure our knowledge outside of our minds. They are not just external to us but also portable, designed to function as representational resources.

Western notions of reality are thus only part of the features of cognitive mappings for other cultures. There are other social and cultural aspects to maps. While modern day mapping professionals view the maps they make as an objective and accurate abstraction of reality, maps are actually culturally specific and socially constrained. They are designed via social conventions for a specific audience, and are abstracted to help people's cognitive mapping.

One example of a cognitive map as a socially specific and culturally constrained artefact is the Aboriginal painting. Aboriginal Art online (2004, para. 9), an online website, described the relationship as the following:

Nearly all Aboriginal art can be related to landscape and some paintings and designs do represent explicitly the physical relationship between different features of the landscape. However, Aboriginal paintings should be seen primarily as maps of conceptual relationships that influence the way the landscape is seen and understood. When Aboriginal paintings do represent specific features of landscape, they show them in their mythical rather than their physical relationship to one another.

A map certainly plays an important practical part in navigating virtual environments. Disorientation in virtual environments is a frequent and troubling issue for many users, an issue noted by various writers (Darken, 1996; Darken and Silbert, 1996; Elvins, 1997; Vinson, 1999). Virtual environments, even those with Head Mounted Displays (HMDs) and motion tracking, lack many orientating features of the real world (Vinson, 1999).

However, both Modjeska (1997) and Elvins (1997) argued that maps in virtual environments should serve merely as abstractions of reality. They both believed

that navigation will be more usable if maps are similar to the way our spatial memory is created, recalled, and acted upon as part of a decision making process.

For example, Modjeska (1997, p. 2) defined navigation via locomotion and wayfinding:

...a useful definition of navigation in electronic worlds: locomotion + wayfinding.

Locomotion is the activity of moving from one location to another.

Wayfinding is primarily a cognitive process, comprising three abilities:

- cognitive mapping or information generation to understand the environment
- decision making to structure and plan actions
- decision execution to transform decisions to behavioural actions.

Rather than seeing wayfinding as a process, Elvins (1997, p. 1) may have seen wayfinding as a type of ability:

Wayfinding is "the ability to find a way to a particular location in an expedient manner and to recognize the destination when reached", i.e. navigating with spatial knowledge and a destination in mind.

There is also confusion in the literature over whether a cognitive map is the process by which people store navigational knowledge, or whether it is the instantaneous product of cognitive mapping, i.e. a cognitive map is formed in the mind on demand from cognitive mapping processes. Lagoudakis (1998), for example, seems to have defined a cognitive map as the former; but Soini defined it as the latter, 'a product of this [cognitive mapping] process at any point in time' (Soini, 2001, pp. 227-228).

Medical research indicates that Soini is more likely to be correct; cognitive maps are created on demand as their elements are retrieved from different parts of the brain on demand. The researchers Wang et al (2001, p. 191) wrote, "Space is represented in the mind not once but multiple times, not unified but segmented."

Soini further distinguished between the term 'mental map', as those maps that people draw when they are asked to sketch out their cognitive maps, and concept maps. Soini defined (2001, p. 229) a concept map as "a graphic system for understanding the relationship between concepts."

Soini also defined symbol mapping, as freehand mapping of places visited by selecting symbols that represent different personal meanings, such as 'nice', 'beautiful', 'private', etcetera. She suggested there may be many interesting 'hybrid' ways of combining (and evaluating) these different types of mapping. In fact, Billinghurst and Weghorst (1995) have previously evaluated engagement by qualitative and quantitative measurement of 'sketch maps'. Their research indicates

that accuracy in sketching the virtual environment after the experience is directly related to engagement in the virtual environment.

Given her thorough investigation of the terms, this thesis will follow Soini's definitions of mapping, and refer to a person's cognitive navigational knowledge as cognitive mapping, the image or schematic they process from their cognitive mapping processes on the fly as a cognitive map, and their drawn interpretation of their cognitive map as a mental map. Mental maps could include sketch maps, symbol maps, iconic maps (symbols with no specific personal connotations), or concept maps.

It is important to stress that cognitive maps are not the same as maps created by professional cartographers. Neural research by scientists on monkeys indicates that we remember locations in terms of salience (behavioural significance) not by what is actually there (Gottlieb et al, 1998). Thus, the way we access these cognitive maps is typically not just via quantitative estimates and measurements but also in relation to personal attachments and perceptions (Wang et al, 2001). For example, Bishop and Green (2001, para. 3) have written:

The Australian landscape is shaped by the values of the inhabitants'...people's values change with their changing perceptions and understanding of the landscape.

Raubal and Egenhofer (1998, pp. 895-896), summarise the wayfinding literature and emphasise the distinction between "practical space (i.e., acting in space) and conceptual space (i.e., representing space)". They refer to Johnson's belief that wayfinding is developed by habits and social practices (Johnson, 1987) along with image schemata, 'recurring mental patterns that help people to structure space so that they know what to do with it' (Raubal and Egenhofer, 1998, p. 896). Image schemata and socially ingrained wayfinding are for them elements of Naïve Geography, which aims to develop 'formal models of geographical information space that match closely with human cognition.'

For example, Dale and others at the Centre for Language Technology, of Macquarie University, have researched the usability of automotive, Internet, and PDA navigation systems. From experimental research they identified three key differences between computer and human directions, and built a machine that used much more 'humanistic' descriptions (as reported in Welsh, 2004).

Maps in virtual environments may be needed, and they are indeed capable of providing better affordance for cognitive mapping, but they also offer other advantages over real world maps. Being interactive, recordable, and dynamically personalisable, digital maps can gradually or contextually reveal the unknown, keep a personally relevant record of the past, or offer a shadowy gate to the future.

A foreteller of what lies ahead, or what is a worthwhile digression or quicker way around a yet to be seen obstacle, real world maps help 'preview' possible and optimal journeys. Yet digital maps used for previewing (wayfinding) can also be directional and proxemic. As users progress through the virtual environment, a digital map could improve in local accuracy. This feature is already used in certain types of games, and could help sustain mystery, but also reduce cognitive loading. For example, imagine that on entering a virtual environment for the first time, that the map is faded and only shows a very blurry concept of what is in the area, as found on maps by neighbours. As one explores the virtual environment, the map becomes more accurate.

Digital maps could also be related more closely to a sense of place. Consider a virtual environment with dynamic place elements that both afford and constrain progress. Changes in lighting could symbolise day and night. Night-time could be the metaphorical resting time when a user needs to find a safe place to sleep (recharge). Coupled with an interactive digital map, the user could be induced to plan and record (via the map), all paths and journeys so that they do not fall into a stupor in a dangerous place (from which they cannot move or wake).

Any device for orientation will help users navigate through an environment, but an interactive digital map may further allow a graphical history of their virtual travels. For example, Ramloll and Mowat (2001) created a virtual environment where participants could take in-scene snapshots of exit and entry points. They could retrieve these snapshots at any time and click on them to move to those specific locations. The writers reported that this function increased ease of navigation.

On the other hand, Nitsche and Thomas (2003) described a project that uses cinematic devices and teleporting assailants to confuse and hinder the participant's mental mapping of an environment. They believe these steps increase dramatic tension, and help make small environments appear larger (and hence more interesting for the participant).

Further, unlike typical conventional maps, digital maps can automatically filter information according to one's current position, individual preferences, or hidden (or targeted) events in a virtual environment. They can also be used like an inventory, to keep a reminder of what options or resources are currently accessible.

In the sense that maps can act as memory aids to wayfinding, they are also 'memory' maps, graphical travel diaries. Digital interactive maps can help orient, navigate, and recollect past episodes along a journey. Digital interactive maps can also 'remember'. Such memory maps could record vistas, landmarks, use of artefacts, and encounters; they can act as a form of pictorial diary. As an aid to

memory recall, users may select, scale, and position thumbnail icons of events, encounters, or artefacts onto their map.

For example, users could customize from a palette of icons (castles, houses, bridges, food sources et cetera), and select, scale, and position these pictorial icons to remind them where they went, what they did, and where the safest routes are found.

Further, as artefacts, the way maps are used, personalised, and aged, are 'traces' of their 'life-history'. Maps are epistemic artefacts to aid perception and decision-making, but in being used, they reflect popular and annotated points. Most importantly for us, an interactive personalisable map could show where people went, and how effectively they avoided the areas dangerous to their metaphorical 'health' points in the above game-style scenario.

Further, the cognitive map (as it is called in Human-Computer-Interaction studies and town-planning literature), is a long-accepted model of human wayfinding and hence an appropriate tool to evaluate. While research indicates there is no one primary map, the same research does indicate that our cognitive mapping is multimodal and hierarchical. Given this, it seems reasonable to presume that a multimodal graphical mapping device that people indirectly customize (indirectly as the customisation arises through task selection), will enable the navigation to be more intuitive and hence usable.

Any device for orientation will help users navigate through an environment but a map further allows a graphical history of their virtual travels. If actors are asked to manually select scale and place icons to represent where certain activities or important cues are, then we might be able to track via the size and placement of icons some degree of their engagement.

One type of evaluation is the 'speak aloud' method. By extrapolation, digital maps may help a 'talk aloud' method. A digital interactive map can help users graphically plot the quickest or most scenic journey without entering hostile or physically arduous areas (i.e. an environment with physical constraints). When users are asked to lead others through the virtual environment, using the 'teach aloud' evaluation method, the map will help as a visual teaching cue.

Users could update the memento maps with their own sized positioned and scaled thumbnail icons. These icons when clicked on will hyperlink to the time and location of the event encounter or landmark recorded. The frequency, accuracy, and sizing of icons will indicate their amount of care and concern with the landmarks. Once their virtual journeys are over, memento maps could be downloaded to more portable media (for personal later journeys in the real world), or they could be sent

to friends and family around the world so loved ones could track the virtual paths and annotations of real world travellers.

7.4 Suitable Research Areas

7.4.1 Limitations and Central Issues

As mentioned in the introduction, there are many technical limitations to virtual environments, especially those available online. Game technology is surprisingly advanced and spans multiple platforms and devices, but it still needs to improve.

However, the major issue restricting engagement, in the opinion of many people, is suitable contextual interaction (Gillings, 2002; Adams, 2004). Human computer interaction research (HCI) straddles technology and content, but it seldom offers new design insights into improved content. Rather, it has a tendency to improve access to that content.

Academic research does not often accommodate market research implications or always consider the media specific nature of communication (for example, the Cross Media questionnaire by Lessiter et al, 2001). In the writings of HCI specialists like Nielsen, usability is seen as incorporating usefulness, but user preference or preferability (which products, interaction, interfaces, content etcetera that people prefer) is seldom researched or offered directly to the public.

For virtual heritage and travel environments, cross-disciplinary cooperation between domain specialists and evaluation specialists is required. For the goal is not just the presentation of objects or creating engaging activity, but also the communication of meaning and significance. This leads me to suggest that for virtual heritage environments the crucial issue is interaction and the learning that results from that interaction. Table 12 shows how this thesis has approached these issues, and the last two rows are in grey to indicate that these issues are still relatively vague and undefined. They offer particular interest to researchers focused on issues of heritage and historical content.

Table 12: Evolution of Thematic Design Issues

Thematic Topics	Issue: How to obtain the following
Place	Quantity and salience of data that evokes place
Photorealism	Quality of appearance of that place-data
Cultural Presence	The feeling of social and cultural inhabitation or visitation of that place
Game Elements	How one interacts with the place as a setting that increases the engagement (entertainment factor) of some activity.
Learning Mode	The type of interaction resulting from that interaction
Cultural Learning	Type of knowledge acquired from that learning mode

This thesis has argued that the development of virtual environments has been problematic in terms of the above issues, rather than purely in relation to realism and accuracy. The early virtual environment designers worked out which representational elements made up an environment, and what levels of detail and realism were required. More recently (and particularly for game design), they have attempted to wrestle with the issues of agency: how are people embodied, embedded, and challenged?

As more and more people start using three dimensional environments instead of the currently popular online two dimensional (text-based) communities, designers will be challenged with how place itself communicates meaning. This question is highly complex (as indicated by grey in Table 12), and extremely contextual. To what extent can users enrich their environment by personalising it and communicating through it? To what extent should users be thematically constrained by the environment itself? How much individual freedom will the users have to interact with the environment even though this freedom may destroy the environment's thematic constraints and affordances?

7.4.2 Preference Testing Place Elements

This thesis suggested environments become more interactive and thus more engaging by adding dynamic place elements, memento or memory maps, physically embodied and socially embedded avatars, scripted agents, and challenging goals accomplished by completing culturally constrained tasks.

In order to increase the sense of cultural presence designers may be able to learn how to utilise the above elements by applying the interactive mechanisms commonly used in computer games (social agents, levels of interaction constraint, and task-based manipulation of artefacts) to virtual heritage environments. Possible examples include allowing the changing factors in dynamic environments to have an effect on how people move through virtual environments through the metaphorical notion of 'health points', 'constraints' and 'affordances' as borrowed from game design theory.

Another example would be to use scripted agents as dialogue, to help the human participants via appropriately worded questions. People could also update the memento maps with their own positioned and scaled icons. They may also view the effects of how they choose to complete tasks via the artefacts at their disposal. Creating a world of 'augmentable history', where individual autonomy and remembrance of individual actors is integrated with actual historical events and figures is also possible.

In a virtual heritage environment then, the setting should also be an interactive artefact; participants should be able to interact with the environment as much as a local. In games (by contrast), settings are backdrops. Actors (active participants) could exchange maps with each other of the best places to visit, and access audiovisual descriptions and instructions of how to use artefacts. Real-time events could trigger historical events (historical events could depend on real-place change, like freak floods or extremes of temperature).

Designers could also attempt to create a sense of physical embodiment for the visiting participants. Implementing variable factors in dynamic environments can have an effect on how people move through virtual environments through the metaphorical notion of 'health points' as borrowed from game design.

Direct or indirect lights might glow or proximity-sound triggered when participants approach important paths or tools. As with action-based computer games, there can be damage areas, territorial restrictions on wandering, and sacred spaces that are off limits or change the navigation or exploration capabilities of the participants.

Avatars could change their appearance or ability to perform tasks at certain times or in proximity to key objects and events or when more culturally embedded perspectives are required. Visitors may be able to use scripted agents as dialogue aids to help guide users who ask appropriately worded questions.

Participants might be able to solve tasks in order to travel back in time ('reverse time travel'). Designers could also allow the participants to view the effects of how they choose to complete tasks via the artefacts at their disposal.

As mastery grows, and less is known (as participants travel backwards into the dim past), more interactivity is possible. Designers could create a world where individual autonomy and remembrance of the participants is integrated with actual historical events, and with historical figures ('augmentable history').

One could also use memory-based mapping (two dimensional maps of the local area fade in and out depending on how long ago the actor was there) so that the actor is not cognitively overloaded. Overlays can also be used to highlight objects

or add task-related or even character-based information. In order to make the experience more engaging we could allow people to update personal 'memento maps' with their own positioned and scaled icons

Designers could also gauge the effectiveness of each element to record the engagement and performance of participants. For example, by allowing people to choose the type of map, designers can test user preference between conventional and schematic memory maps.

One could argue this issue of place information is an issue of salience, or of realism. Designers may wish to evaluate realism across Media, audience preference for realism versus Interactivity, or realism versus Phobic Triggers. Virtual environments in popular literature are often personified in terms of sensory overload (from the Matrix to Neuromancer, they stem in effect from examples of the mathematical and dynamic sublime cited in Kant's Critique of Judgment).

However, creating vast amounts of information requires vast amounts of processing power. Instead, it would be useful for research to provide designers with information on engaging 'triggers' so that only highly effective interfaces are needed to stimulate the participant's engagement. Such triggers may include the recreation of native tools and locally specific goals socially embedded, and a sense of physical embodiment during interaction (through collision, acoustic feedback etcetera) and how challenging they are to undertake and accomplish ('hard fun').

It is one thing to list the above scenarios, evaluating the above ideas against each other or against various mutations of themselves may be problematic. Such testing may tell designers for certain specific contexts which elements are preferable. Only designers do not yet know how appropriate they are to the content as it affects the required learning experience, for what the required learning experience ought to be has not yet been discussed.

7.4.3 Education as Entertainment

Highly interactive, games offer built-in assessment of task performance so they are suitable for evaluations of navigation and manipulation through complex spaces. Educationalists often use games to promote 'parallel thinking' (Prensky, 2001). Games can remember you (the player), and the game environments can be personalized. In terms of technology, they offer economy of size, hardware support (acceleration), cutting-edge graphic rendering and artificial intelligence, dedicated user forum-based help, multi-platform code and networking.

However there are issues with games; in many, participants destroy rather than create cultural context. Teamwork is often limited to strategic destruction, and

most importantly, games do not change ways of thinking in relation to a culturally appropriate setting.

Researchers in Artificial Intelligence and in anthropology such as Schank (1990), and Miller (1999), believe participants can learn about a culture through dynamically participating in the interactions relating to a cultural setting (a place that indicates certain types of social behaviour), artefacts (and how they are used), and cultural learning.

The significance of a place is often learnt by social learning (by people telling you or instructing you), by trial and error, and by observation. People often learn from being taught the rules and parameters of a social background through older members instructing them on how to behave (using dialogue devices such as stories and commands), and this instruction eventually becomes integrated with the disciple's own personal motives.

Once these conventions have become embedded, participants only need to perceive certain cultural cues (even independently of people) in order to recall and invoke certain social behaviours.

Designers could attempt to provide for cultural learning via these different means of transmission and evaluate which ones are most successful for particular audiences and contexts. It may be that certain types of interaction do not fit this schematic pattern or use all three, or that the audience members' learning styles conflict with the type of interaction available.

However, it is not yet known whether peopling an environment (adding other players), adds to or subtracts from the sense of authenticity and engagement.

7.4.4 Indirect Evaluation

Academic virtual environment evaluation usually involves requesting test users to fill out questionnaires indicating a level of presence against three, four, or five general criteria (a feeling of physical space, negative feelings, social agency, naturalism or realism, and engagement).

Questionnaires are prone to error. Evaluating people after their experience of the virtual environment may be prone to error, as it relies on memory recall and on their noticing and communicating exactly what made their sense of engagement seem powerful, weak, or non-existent (Slater, 1999).

If a virtual environment seems 'natural' to viewers, they may not notice important features that a trained expert would consider distracting or ineffective. Designers need 'passive' evaluation mechanisms to determine the level and type of engagement without breaking that level of engagement.

This thesis has argued that in games abstraction can be just as engaging to users as a sense of realism. Further, as users become engaged in the tasks, it is easier to observe them without damaging their level of engagement, especially as games traditionally have built-in evaluation mechanisms. However, there are issues in applying evaluation techniques to learning about culture, and they are discussed in the next chapter.

7.5 Summary of Design Elements

'Africa loses a library when an old man dies.' (Hampaté Bâ). (UNESCO World Heritage website, 2005).

Virtual heritage requires an understanding of what is 'historical'. How do designers capture it (if, like Bâ, one can believe it is often based in minds more than in books), and how do designers invoke the feeling of encountering it as something either new or familiar? Designers need to know how to create a sense of embodiment, and to what extent they need to constrain and embed the visitor as a social actor in a context that can be highly fragile, ephemeral, and intangible.

For virtual heritage projects, and for virtual environments to some extent, the central issue appears to be learning about others and how that can be supported via digital media. Cultural presence involves learning intangible heritage information- how is this possible via digital media?

For creating a virtual environment with a notion of a 'place' (a region recognisable to a user as a culturally coded setting), merely identifiable or evocative virtual environments is not enough. A virtual environment must allow visitors to see as much as possible through the eyes of the original inhabitants. It must also suggest ideas of thematically related events, evidence of social autonomy, notions of territorial possession and shelter, and focal points of artefactual possession. In other words, the virtual environment must provide a perspective of a past culture to a user in a manner similar to that deduced by trained archaeologists and anthropologists from material remains (fossils, pottery shards, ruins, etcetera).

There are certainly large gaps in the knowledge of what would make the experience more engaging and educational. The components of virtual environments could be tested to see how well they afford authenticity, realism, engagement or learning in virtual places. Evaluators could also test discernible change in learning or entertainment acquired using different types of interaction, or evaluate user preference or user ranking of presence criteria when presented with different types of virtual environments.

Yet we still do not have a full range of contextual evaluation methods. Virtual heritage is seldom evaluated since so many resources and so much prestige is built into what so often turns out to be a fixed (i.e. not alterable after the fact) product. More research is needed to determine which forms of interaction and type of depiction are more compelling, task-effective, useful for cultural presence, and optimal for learning purposes.

However, there are at least four major design criteria that such a prototype would need to aim for. These criteria are embodied and physically responsive places, socially embedded and challenging constrained tasks and goals, some degree of hermeneutic enrichment, and an unobtrusive way of evaluating engagement.

Some of the techniques used in computer games may help. The exploration of the environment can be traveller rather than tourist based (that is, the participant is given tasks to complete), and there may be design elements of game-style interaction that can also increase engagement in virtual heritage environments.

Computer game environments do not typically attempt the hermeneutic components; this seems more a feature of online communities. However, games do offer some form of social context, embodiment, and challenge. According to Aldrich (2004, p. 14), they are also simulations:

If you want to understand simulations, the only way to do it is to become familiar with today's computer games.

This thesis has suggested that dynamic place elements, constrained tasks and goals, social agency, and contextual artefacts (preferably using epistemic artefacts such as maps), might address these criteria. It has also indicated how these design elements might help evaluation of the participants. In order to resolve the above objective, a game-style method is proposed that incorporates tasks and artefacts to increase user engagement and to educate them on how residents have manipulated the environment.

Obviously a prototype would not be able to comprehensively accomplish all of the above, so the experimental design will focus on comparing different types of interaction inspired by the tripartite cultural learning schematic (outlined in Table 8: Interaction Learning Modes in Games). It will also compare the learning achieved via various evaluation methods in order to ascertain which one is the most effective evaluation strategy.

The results from this research will hopefully indicate whether 'Virtual Travel' can help the understanding of another inhabited place using 3 modes of interaction (observation, exploration, and instruction), which mode is most interesting, which affordances and constraints work best, and whether personalization is essential to a

sense of engagement. Do the results vary according to audience? Did the varying interaction modes allow them to gain a culturally embedded new world-view?

8.1 Testing That Which Is Not Yet Fully Tested

...researchers and commentators have not yet begun to grapple with the question: What does it actually mean to describe something as *virtually real*? It is my contention that until they do the unique potential VR has to change the way we approach, study and think about the physical world will not be fully exploited...archaeological use of VR is at present all about the creation of pictures. (Gillings, 2002, p. 17).

There has so far been little research into evaluation best suited for assessing and improving the experience and learning of participants in a virtual environment (Bowman, Wineman, Hodges, and Allison, 1999), and even less work done on virtual heritage environment (Mosaker, 2001; Roussou, 2004). There are many usability techniques in related fields, in Presence studies, in Human-Computer Interaction research, and even in Ethnography. Yet the particular issues and demands of digital simulations of past cultures or exotic places necessitate specific and careful examination of user needs, technical feasibility studies, and appropriate content on a case-by-case basis.

There is already a large body of work on how artefacts and sites are best recorded and preserved. It is self-explanatory that virtual heritage environments are concerned not just with recording and preserving but also with transmitting cultural information.

There is also evaluation of user-experiences in museums, and via their websites (Goldman and Wadman, 2002). Yet this work tends to focus on travel information, not travel experience, and certainly not on the cultural learning experience itself. There is still work to be done on what is cultural information, how it can be interactively experienced, how it is best experienced and learnt, and how to determine the strengths and weaknesses of a virtual heritage environment's ability to provide a cultural learning experience.

8.2 Evaluating Cultural Learning

The reader will recall the following definitions (although open to argument) made at

the start of this thesis.

Culture: Culture expresses shared beliefs and ritualised habits of social agents towards each other and their environment via artefacts and language. Cultural behaviour is a subset of social behaviour (behaviour between two or more people), where behaviour is governed by or understood in terms of a cultural setting involving the constrained use of artefacts.

Cultural learning could be summarised as learning through observation, instruction, or by trial and error. Therefore, there are two major ways of transmitting culture: through other social agents (through the language actions and reactions of other people), and through artefacts, (the objects created and modified by people). The former seems necessary for understanding a culture natively (from the inside as vicarious experience), and the latter seems necessary for extending cultural knowledge or developing cultural awareness of alterity (from the outside as observation or as extrapolated experience). The notion of cultural learning as a spectrum covering awareness to understanding, and nativity to alterity is also important for evaluation, even though it is seldom made (Relph, 1976; Champion and Dave, 2002).

Virtual heritage projects are a subset of virtual environments, so it may be helpful to study how the latter are evaluated. Many evaluations of virtual environments measure a sense of 'presence'. Presence is often defined along the lines of: The subjective sensation that one is 'present' in a three-dimensional environment that is mediated by digital technology. Presence has also often been described as the sensation of 'being there' in a virtual environment. 'Being there' is usually tested as a combination of factors: social presence, engagement, negative feelings, spatial presence etcetera in a virtual environment, (Slater, 1999).

8.3 Virtual Heritage Evaluation

A further dimension of presence often mentioned in conjunction with multi-user environments is the notion of copresence or social presence. There is disagreement in the Presence Research community over these terms (<http://www.presence-connect.org>).

Co-presence can only take place within a system where you have the sense of being in another place or environment other than the one you are physically in and being there with another person. This differs, in my view, from social presence.

Social presence is rather the degree to which a person experiencing a virtual environment feels part of potential or actual social interaction with at least one

other being also capable of social interaction and/or the degree to which they see social interaction (mutually perceived and understood) between two or more intelligent beings. Cultural presence, on the other hand, is the feeling of being in the presence of a similar or distinctly different cultural belief system.

As described in section 4.5, this notion of cultural presence is new, and especially suitable to evaluating virtual heritage environments. For this definition specifies a goal, to measure the change in understanding of another cultural perspective different to one's own. Further, we need to measure the significance of that change in perspective and in knowledge, and the effectiveness of the tools and methods required to effect this change.

It must be stressed that this measure of change would be evaluated from at least two different viewpoints, the etic and the emic viewpoint. Etic means an outsider's (a stranger's) view of a culture. More specifically, it is used to describe the anthropologist's method of describing cultures from their own external cultural perspective. Emic means the converse, an insider's (a local's) view of their own culture's inter-relationship of concepts and meanings. In anthropology, it is used to describe the relevance and meaning of concepts and categories from within the same cultural perspective.

When we judge the strength of cultural presence, our judgement can be etic or emic. Cultural presence may cover a spectrum of understanding and viewpoint (from etic to emic) with varying intensity. It may be felt, understood, or entered unself-consciously, empathized with, or observed but not understood.

8.4 What Types Of Evaluation Are There?

8.4.1 Expert Testing

Expert testing is usually done via cognitive walkthroughs or heuristic review. A cognitive walkthrough is a sequence stepped through by reviewers (House, Butler and Schiff, 1996). While it is preferable to have cognitive walkthroughs undertaken by domain experts (visualisation experts, archaeologists, or cultural historians), who then suggest ways of improving the intended design, it can be difficult to obtain such a range of expertise.

Nielsen (n.d., para. 1), defined heuristics as "a usability engineering method for finding the usability problems in a user interface design so that they can be attended to as part of an iterative design process." There are indeed heuristics for web-design, but they are based on a long history of creating HTML pages. Usability standards for evaluating not just usability but also usefulness for three-dimensional

environments are still some time away.

8.4.2 Content and Media Comparison Studies

In a similar manner, it is very difficult to compare virtual environments with other media, few are comparable, few have the same objectives, and few mediums have the same constraints or public expectations (Christiansson, 2001). Until there is a significant and substantial collection of virtual environments with similar aims and objectives, it may prove fruitless to attempt content comparison reviews, even if there have been cross-media presence surveys (Lessiter et al, 2001).

8.4.3 Physiological Testing

In their summary of presence evaluation measures, the International Society for Presence Research (2003, para. 7) wrote that there have been several papers in presence studies on capturing presence using "changes in skin conductance, blood pressure, heart rate, muscle tension, respiration, ocular responses, posture, and so on." However, presence may not directly equate to physical or physically observed mental changes (Schlögl et al, 2002), and it certainly does not directly tell us whether virtual heritage environments are causing changes in cultural awareness and learning.

Although it can be non-invasive, results can be unclear (Meehan et al, 2002). Slater et al (2003) highlighted a typical problem with this form of testing:

The problem with using physiological measures directly as a measure of presence is that it is not clear what the response should be in mundane situations. The expected physiological response to a stressful VE is one thing, but what is the expected response to being in, for example, a virtual simulation of an ordinary hotel room, just like one you've stayed in dozens of times before, where nothing out of the ordinary is happening?

8.4.4 Task Performance

Tasks are often set to record the participant's performance in solving them, in order to ascertain the degree of usability of the project. The term 'usability' has achieved a great deal of fame via the website of Doctor Jakob Nielsen (Nielsen, 2003). He defines usability as having five components: learnability; efficiency; memorability; errors (how many and how severe); and (subjective) satisfaction.

He also mentions there are other factors, such as the highly important factor of utility; does it do what users want? Nielsen's suggestion for basic user testing is to test the project with representative users, and ask them to perform tasks. One could rephrase the above as an evaluation of effectiveness (how well the user achieves the goals they set out to achieve using the system), efficiency (the

resources consumed in order to achieve their goals), and satisfaction (how the user feels about their use of the system).

Typical virtual environment usability research (Bowman et al, 1998), tests one audience (say 10 people), with three different techniques to solve a certain number of tasks (such as navigation or object manipulation). When evaluating task performance against technique selection, the permutations may become overly complex. The tests were conducted using simple environments. Hence, the complex interdependent features of the environments may produce significantly different results. These specific results may thus not be generally applicable and test usability, not usefulness. Are there discrepancies between usefulness and usability? Would contextual constraints be useful or educational for users?

8.4.5 Surveys/Questionnaires

There are several issues with questionnaires. Slater (2004) has both used them and criticised them. He has argued in the past that one can evaluate presence through asking subjects to rate their feeling of being in another place, but he now believes their value is negligible. Questionnaires interrupt the engagement of participants so they are used at the end of the experience rather than during the experience itself, but this relies on memory recall and a succinct understanding of what actually happened (Slater, 1999).

In addition, Presence criteria are usually evaluated using questionnaires, but large test audience numbers are not always available to the designers of virtual heritage environments. Some researchers also use a Prequestionnaire to gain demographic data and an idea of user expectations (Kim, 1999).

8.4.6 Ethnographic Evaluation

An alternative method, as suggested by the International Society for Presence Research (2003), is an ethnographic approach. For example, in Ethnography and information architecture, Rettig (2000) argued that information design tools were very similar to those used in archaeological and anthropological research.

These tools are observation (shadowing, people watching, examining 'artefacts'); interviews (contextual, story telling); sampling (randomly, users are asked to sample events); and self-reporting (users take pictures or keep journals etcetera). There are also a growing number of papers in applying discourse analysis and ethnographic observation on multi-user online game environments such as MUDs (Manninen, 2003). The danger is that one could be evaluating social presence (how effective the virtual environment is at supporting social communication), rather than cultural presence (and how well it supports learning different cultural

perspectives).

8.5 Evaluating Virtual Heritage Environments

Virtual heritage environments are designed for an end user, but it is not always clear what the end user requires. Pletinckx (2003, slide 10) answered this point:

What does the user want? Experience the past....in an accessible way....with scientific accuracy....through sustainable techniques....linked with the community.

People intending to travel to a site may have different requirements to people just exploring a virtual environment (VE). Designers may want to use virtual environments in different ways; used offsite to understand a past, imagined, or present site, inspire them to visit the real-world site through past, present, or imagined depictions, create as background for an online community, or use onsite to augment the experience. Which features are necessary not just for efficient usability, but also for onsite and offsite usefulness?

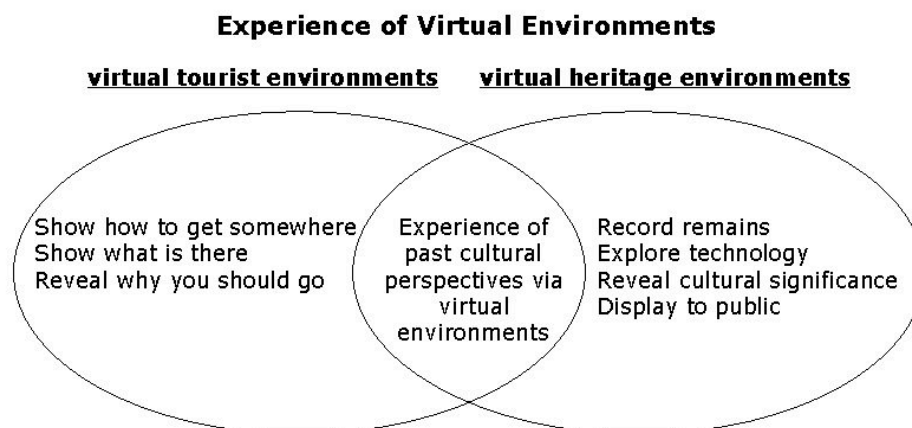


Figure 5: Diagram of Travel and Tourism in a Virtual Environment

While the above diagram (Figure 5) may suggest virtual tourist and heritage environments have much in common (and indeed they do), it also highlights their differences. The former is more focused on travel information, while the latter is concerned with travel experience.

An evaluation of virtual heritage projects by Mosaker (2001) indicates interactivity and personalisation may be more important than realism. Yet virtual heritage projects do not typically involve carefully modulated and monitored levels of interactivity. Hence, we do not know which method of interactivity is most appropriate, for varying audiences, mediums or recreated objects.

8.5.1 Task Performance and Game Evaluation

I have argued that game-style evaluation may help us assess user performance without interrupting their enjoyment of the virtual environment. Unfortunately, this seems a relatively new area for research as a paucity of literature exists so far on this subject. Case studies of learning via game-style simulations exist (Aldrich, 2004), as well as descriptions of how we learn via video games (Gee, 2004), so it seems only a matter of time before performance evaluation can be conducted contextually and indirectly.

Being able to monitor user performance, and what they prefer to select or solve without disturbing their engagement in the experience could be included in virtual heritage environments. For example, in games, data is gathered by innate interactive mechanisms (chat logs, health points, completion of the memento map, and the final state of the inventory of artefacts).

Such data could be compared against results from a pre-experience and post-experience user evaluation questionnaire to determine if we can gain user feedback on cultural immersion in virtual heritage environments without their enjoyment being curtailed, and without them being forced to participate in laboratory interviews or complete survey forms.

One possible long-term solution is to create a database that records user-interaction. This interaction is to be with artefacts (objects in the virtual environment), the places users visit (a record of places changing with the passage of time and use), and dialogue (interaction) with agents (avatars of computer-simulated people) that users meet.

We could use the mechanisms outlined in the last chapter to evaluate indirectly both task performance and user engagement. Through such mechanisms, we could assess effectiveness by the resulting score or collected artefacts gained or lost by users in their attempt to solve tasks of navigation or dexterity. A record of options selected by users may indicate user preference. The extent to which a map is uncovered or proximity triggers are discovered next to items of information may indicate preferred navigation. Chat logs of dialogues with avatars linked to artificial intelligence databases may indicate how effective users are in eliciting information from the 'chat-bots'. Artefact selection may indicate user knowledge of what is appropriate. The speed by which tasks are solved may also help indicate user satisfaction.

Further, in test conditions we could provide for a range of interaction tools. We could evaluate their 'preferability' at the end of the evaluation by recording which

tools are selected by users for the next would-be stage of the virtual environment. This method could be called 'evaluation via exit selection'.

We could also evaluate task performance tied to changes in physiology where deliberate control of the later is required in order to navigate or manipulate objects. For example, Char Davies' artistic work *Osmosis* uses breathing to rise or lower oneself (Davies, 1998).

We now have the possibility of adopting biosensors (that are already appearing in commercial games) for virtual environments. Biosensors used in a research-setting offer up a range of interesting possibilities for evaluation and contextual interaction. Still, there are specific issues with evaluating say cultural presence that are not addressed by physiological testing. It is not clear how awareness of cultural presence in a virtual environment can be indirectly ascertained. Changes in brain state, heart beat, or skin temperatures do not necessarily mean the participant is either increasingly aware of cultural presence, or is increasingly knowledgeable or skilful about a new cultural perspective.

8.5.2 Statistical Methods Suitable For Virtual Heritage Projects

Gabbard et al (1999, p. 41) wrote:

Clearly, performing usability evaluation on non-traditional interactive systems requires new approaches, techniques, and insights. While VE evaluation at its highest level retains the same goals and conceptual foundation as its GUI predecessors, the practical matter of performing actual evaluations can be quite different.

Firstly, as virtual environments, one would expect virtual heritage environments to be open to similar statistical evaluation and such evaluation to be presented at related conferences and in relevant journals. There are conferences that cover the design and development of Virtual Heritage environments (VSMM, VAST), effective and usable museum learning experiences, (VSMM and iCHIM conference proceedings), HCI methods and evaluations, and the notion of presence in virtual environments (especially papers from the International Society of Presence Research conference proceedings).

In particular, Virtual Systems and Multimedia (VSMM) Conferences have special sections devoted to Virtual Heritage. Yet of the papers and articles that explain they use statistical methods, few of these papers evaluate the learning of the participants; none of them evaluate cultural presence and understanding as discussed in this thesis.

For example, in the Virtual Systems and Multimedia (VSMM) 2003 proceedings, of

ninety-three papers, twelve papers describing virtual heritage projects appeared complete enough to have been subjected to user testing and inferential statistics, yet none of them mentioned statistical evaluation or even comprehensive user testing. There were however two virtual environments that had non-heritage content, that conducted user testing, (Thwaites, 2003; Lee and Kim, 2003).

The Thwaites paper tested 44 subjects, with a Likert scale questionnaire and open-ended questions, on a Char Davies VR art work, but the questions concerned issues of transparency, feeling affected, self-awareness, navigation, or feeling ill, no questions related to culture or learning. There was no statistical calculation mentioned (which is understandable, given the experimental and aesthetic focus of the work). The Lee and Kim paper used a Likert questionnaire with ANOVA statistical method, on whether explicit descriptors, traces or affordances were subjectively considered to help create the sense of a more interactive environment. The content, however, was not related to virtual heritage, and purely for the sake of the experimental design.

In the Virtual Systems and Multimedia (VSMM) 2004 proceedings, of 169 papers, eighteen papers with virtual heritage content appeared complete enough to have conducted testing and inferential statistics on the user experience. Apart from the author's own paper, three papers said that they conducted user testing.

Sylaiou et al (2004) evaluated an augmented reality museum project using heuristic guidelines and cognitive walkthroughs. Twenty-nine users and ten experts were asked to complete an eight point Likert scale test on usefulness and enjoyability. No statistical calculations were mentioned. Abawi et al (2004) conducted user testing while Ogleby and Quadros (2004) mentions exit polls, but there was no mention of statistical testing, the number of participants polled, or any other numerical details for either paper.

In short, there appears to be a distinct lack of either user testing in virtual heritage environments with statistical calculation of the data. The iCHIM proceedings include papers on usability testing, but they avoid mention of the statistical methods used. Of the papers that discuss evaluation, they do not directly address the user-centred issue of cultural learning; they evaluate navigation and aesthetic issues.

Of the four above areas, research under the auspices of the International Society for Presence Research (ISPR) seems to have applied the most thorough and comprehensive evaluation methods. However, statistical methods were typically used to evaluate Likert-based questionnaires, the focus was on subjective response to a sense of shared presence or co-presence, and the actual content either was designed directly for the sake of the experiment, or did not directly address the

notion of learning about other cultures. A paper presented at Presence 2002 (Riva et al, 2002), outlined a notion of cultural presence, but no evaluation method was discussed.

While HCI is a field that is focused on evaluation, it too has its own internal problems. For example, Hartson et al (2003, pp. 172-173) have evaluated usability methods as a meta-comparison of usability studies, measuring these methods against the criteria of thoroughness, validity, and reliability. They selected eighteen comparison studies and found a surprising number were incomplete or unclear. They conclude (2003, p. 177): "At this point in the HCI field, it appears to be nearly impossible to do an appropriate meta-comparison of usability studies."

Bowman et al (2005, pp. 360-367) have argued that extrapolating guidelines from the 2D world of HCI heuristics to virtual environments may also obscure the distinctive characteristics of 3D virtual environments. They write (2005, pp. 363-365):

3D UIs are still often a 'solution looking for a problem.' Because of this, the target user population or interaction technique to be evaluated may not be known or well understood...Presence is another example of a measure often required in VE evaluations that has no analogue in traditional UI evaluation.

Gabbard et al (1999, pp. 7-9) have also written of the problems that bedevil the evaluation of virtual environments. They have written that it is difficult to discern the target audience, find an actual problem that the virtual environment is trying to solve, or separate expert knowledge from novice knowledge. In the evaluation of the virtual environment they also commented that it is difficult to decide on using within-subjects testing (which means the subjects need to experience many different conditions) or use between-subjects testing (which requires a great deal more subjects to sit the tests). The novelty of virtual environments to most users further exacerbates the problem.

It may be possible to counter the novelty factor of virtual environments by evaluating an experienced group, such as those who have played computer games for some years. Krauss et al (2001) measured presence in a computer game using a modified version of the Witmer-Singer (1998) questionnaire on 170 participants who were asked to remember a computer game they played. This resulted in 163 complete data sets of answers to questions that measured audio and haptic cue, control, ability to use the control mechanisms, and carry over behaviour generated from gameplay that continued even when the participant stopped playing the game. Respondents selected a button for each answer (based on a seven point Likert scale), and these answers were calculated using Cronbach's alpha. The writers said

the sample size should have been even larger, but they also forgot to mention if all respondents played the same computer game, using the same hardware. The paper notes that participants were recruited online to answer notions of presence in 'first person shooters.' If so, it is hard to understand how individual responses could be combined as the genre covers many different games that can be played across different platforms.

Curtis and Lawson (2002) conducted an interesting study on computer-based adventure games as problem-solving environments, and used t-tests and then Partial Least Squares (PLS) to evaluate schema and strategy development of forty participants who were asked to find at least six objects in five minutes. The number of locations reached and objects collected were recorded, as were the extent to which they used maps and the number of moves that they made. The participants were also trained to speak aloud while solving the tasks.

However, their results (Curtis and Lawson, 2002, p. 53) "suggested a strong negative path between Schema to Performance." Curtis and Lawson suggest cognitive overloading or high variability in decision making adversely affected the results but there may also be other reasons. Possibly those who understood the game well were not highly motivated to perform well because they simply were not challenged and intrigued by the tasks set them.

Barfield et al (1995, pp. 482-483) have acknowledged that defining and evaluating a useful sense of virtual presence is still difficult. Their chapter is entitled "Components of the 'Virtual Environment' Experience", however statistical methods described in that chapter measure task performance rather than user experience. In addition, one of the components, Zeltzer's criterion of natural 'task-level' interaction which is apparently related to a notion of how intuitive is the environment, is also task performance based rather than user-experience based.

Parés and Parés (2005) have written that presence research does not typically evaluate the experience of the virtual environment, and their paper outlines a conceptual evaluation method to address this gap. However, they unfortunately do not provide statistical evaluation to verify their conceptual model.

Steed and McDonnell (2003) have written that the emphasis on task performance is typical in presence research. Unfortunately, their attempt in their pilot studies to marry the two commonly used Presence questionnaires (Slater-Usch-Steed, and Witmer-Singer) in order to help answer this question, does not have a suitably large sample size ($n=5$), and the tasks set still seem arbitrary.

One exception to arbitrary task-based evaluation is the evaluation of social presence, a sense of 'other' in a paper by de Greef and IJsselstein (2000), which

uses a between subjects test and statistical evaluation using the General Linear Model to evaluate the variables of presence and satisfaction. However, this thesis is concerned directly with the evaluation of the effect of certain modes of interaction on a sense of cultural presence, and not with social presence as defined in that paper.

Presence conferences have discussed the relation of culture to presence, but not in terms of cultural learning as defined in this paper. For example, Hu and Bartneck (2005) evaluated the effect of cultural background on a subjectively perceived notion of presence. Twenty-four Chinese and nineteen Dutch participants watched interactive movies of a fictional job interview. Each movie had two decision points for the participant to answer, which created four possible movie endings. There was also had a secondary screen of a Lego robot, or the actual Lego robot. In both conditions, screen condition and robot condition, the screen robot or actual robot spoke using speech synthesis software, and looked randomly at the main screen. In the robot-condition, the participant touched the left or right shoulder of the robot to make a decision.

After watching the movie, they were asked to answer questions on spatial presence, engagement, naturalness, and negative effects. Using paired Sample t-tests and Independent Samples t-tests, statistically significant differences between the two groups were discovered.

However, there are serious problems with the experimental design. The claim that the movie was "culturally neutral" because there were Moroccan, Dutch, American, and Chilean actors, is puzzling. The test was in English, and the Chinese participants had been in the Netherlands (where the experimental design took place) for up to two years. Chinese students and teachers at a Dutch university are unlikely to reflect the cultural beliefs and viewpoints of mainstream Chinese society, especially given the sample size, if indeed there is one set of cultural beliefs that can be considered to be 'Chinese'. This example shows the dangers of using small samples for demographic testing.

There are other problems in using questionnaires. A recent paper by Roussou and Slater (2005) studied the learning of children in a virtual environment, and the effect of interactivity on that learning. Approximately thirty children were assigned to one of three conditions, a control, an interactive VR, or a passive VR, and a speak-aloud method was employed. The study had not been completed by the time of writing the paper, but it revealed a problem with questionnaires. For young children, it can be very difficult not just to observe and recall, but also reflect on why they undertook specific actions in the virtual environment.

Methodology

In their attempt to standardise data collection and data analysis, Friedman et al (2005) have listed issues with presence research and evaluation methods, which are relevant to this research. They noted that in presence research there is currently no large scale verification of data. It is hard if not impossible to reconstruct the subjective experience of the user. It is difficult to compare methods as the content is not detailed, made available, or related directly to real life situations; and the experimental design is often not easily replicated.

They suggest that as presence is still a hotly debated term, (for an example, refer Slater, 1999), one requires many evaluation methods, along with questionnaires (which are often unreliable when used in isolation) to catch subjective responses not revealed by objective evaluation methods. Unfortunately, for this research project, Brogni et al focus on evaluation of task performance, and do not recommend and detail a preferred method of data collection and data analysis.

Insko (2003) also argues that due to the many definitions of presence, one should try to evaluate it with as many measures as possible. Insko adds that a good meta-test of questionnaires is to see if they distinguish between virtual presence and real presence. He cites a study by Usoh et al (2000) that evaluated a real office space and a virtual reconstruction of the same office space using the Witmer-Singer questionnaire and the Slater-Usoh-Steed questionnaire.

The Witmer-Singer test failed to show any differences in presence between the two groups, the Slater-Usoh-Steed test "had a higher marginal score for the real compared to the virtual world" (Insko, 2003, p. 115). Notwithstanding this potential conflict of interest, according to Insko a test of virtual presence should return a score lower than if it assessed presence in the corresponding real world, hence the Slater-Usoh-Steed test is more useful than the Witmer-Singer test. In other words, for Insko and the researchers he cites, (Usoh et al, 2000), evaluation of virtual presence is based on an approximation towards real presence.

Interesting as this may be, the test will not necessarily be of help in assessing cultural presence, unless the virtual experience is supposed to tally as accurately as possible with a given and accessible real world experience of that culture. This is a problem if the real culture being simulated no longer exists in one place or at the current time, or if the cultural knowledge is fragmented or only circulated amongst experts and not the general public.

Gaggioli et al (2003) have written a paper on how to evaluate the quality of experience in virtual environments, a topic closer to the research objective of this thesis. They also argued that questionnaires are unreliable, and that relying on people who have never before been asked to measure their own experience or the

content they learnt in a virtual environment, is risky. They also agreed that presence has many different definitions, and that presence is multi-dimensional. Their recommendations were to analyse as many components of the quality of experience as possible, to analyse the relation of virtual content to daily life, to use their Experience Fluctuation Model, and to compare to other evaluation frameworks. However, their definition of culture is reliant on the notion of memes, an unproven theory of cultural propagation, and no data collection and data analysis is given.

In the paper 'Evaluating Soundscapes as a Means of Creating a Sense of Place', Turner et al (2003) evaluated the effectiveness of soundscapes to help create a sense of place, through a simple post-experience presence questionnaire. Forty people were randomly allocated to one of four conditions while listening to a soundscape (while being in a real place, being in that place and speaking aloud, being blindfolded and silent, or blindfolded and asked to speak aloud). The results were simply mean scores per test condition. In another paper from the same year, 'Re-creating the Botanic: Towards a Sense of Place in Virtual Environment', written with different co-authors, Turner et al (2003) evaluated a sense of place using qualitative data. They also took quantitative data, but the paper did not describe the latter, as they did not believe quantitative data was an accurate measure of a subjective sense of place.

Spagnolli et al (2003) agreed with the inherent risk of questionnaires, they noted that asking people if they experience presence relies on the respondents having a clear and coherent notion of their own self-presence, and conventional tests assume that people can describe their sense of presence clearly and accurately. Their paper also suggested a method potentially applicable to cultural learning in virtual environments, with clear guidelines and questions to ask, but they evaluated dialogue not interaction or creation of cultural artefacts, and they don't appear to have conducted any statistical evaluation of the experimental data.

In summary, virtual heritage papers generally seem to avoid detailed descriptions of data collection and analysis of the intended and actual user-experience. Presence research does have a great deal of literature on data collection, analysis, and some discussion of statistical issues. However, these papers are typically derived from laboratory experiments set up purely to isolate components of presence through analysis of task performance, not thematic user-experience.

Where papers talk about cultural or social presence, or about content related learning, they may detail framework and concepts similar to this thesis. However, they either avoid or decry the use of quantitative data. In the case of museum-based evaluations, there is a focus on navigation and legibility issues, but even

when data analysis methods are included, these papers do not typically analyse the content-related notions of cultural presence as experienced by the user, nor what they learn from the experience.

8.6 Summary of Evaluation Techniques

More research is certainly needed on the usefulness of methods of user study and activity modeling in the context of interactivity in VR. As it seems, there have been no relevant studies that we know of that have been specifically aimed at these subjects, except for the one by Kaur et al. (1999). (van der Straaten, 2000, Conclusion, section 4, p. 3).

The first major problem for experimental designs in this area is obvious: to determine exactly what we are trying to improve through the testing of virtual heritage environments. In experimental design related to virtual heritage environments there are a myriad of issues. How can we evaluate the success or failure of an attempt to recreate digitally a past culture? How do we know whether the designer's goal is achieved in terms of the audience?

It is not clear what the experimental goal is. We might say that if we have a definition of culture, what are the outcomes of tailoring virtual environments to communicate a sense of cultural presence? Do we increase the participant's knowledge, or ability to extrapolate socially contextual principles of behaviour?

If say, we wish to find out which independent variable most affords the dependent variable of cultural presence, we need to define this dependent variable as accurately as possible.

Secondly, as suggested earlier, it is difficult to run comparisons of virtual environments against traditional media (to ask for cross-media audience preferences), because the form of interaction and the technology is so different and in some cases alien to the test subjects (Riihiahio, 2000, pp. 101-103). To argue that the content in a film and a game based on that film are comparable, is to conflate narrative with self directed interaction, ignore the atmosphere of a cinema, and equate high tech surround systems with a desktop monitor.

There is also the issue of time; people have had years to build up knowledge of film and television and even computer games. They may also take a long time to build up experience of virtual environments. We could use ethnographic methods or ask people in online communities to compare new interaction modes or new interfaces. Unfortunately, we do not know if they represent the complete spectrum of the potential audience, while their knowledge is typically very specific and accumulated

through unhealthy amounts of time spent online (Yee, 2004).

There is also the issue of which evaluation method to use. For cross-media comparisons, questionnaires are typically used but they can be problematic. Virtual environments are also seen as a 'cool' new technology, and the test audience may be biased towards this new technology, or, conversely, have unrealistic hopes of what is feasible in real-time and online media (due to previous experience with commercial game engines, or watching pre-rendered digital animations in science fiction films).

For virtual travel environments, one might wish to compare them with visiting the real place. One might argue that to evaluate photo-realism a comparison of the virtual place with the real place it attempts to replicate, is essential. However, the logistics of finding an audience that can compare real places to virtual places is often difficult if not impossible. More importantly, as Gillings (2002) noted, the issue is not how Virtual Reality can appear to be reality (i.e. be identical to the place that it recreates), but how Virtual Reality can add to the experience in a new and different way to reality.

Thirdly, in experimental design one typically employs a control group to determine whether a treatment (a new added cause) is more beneficial than the status quo (represented by the control group). For virtual environments, especially virtual heritage environments, such an approach is highly problematic. It can be very difficult to select and sort audiences by background knowledge and skills into equivalent groups (a control group versus a treatment group) for statistical evaluation, and expect initial learning styles, as well as understanding and experience of three-dimensional computer environments to be equivalent without a thorough demographic Prequestionnaire.

If we are evaluating whether a control group using a standard interaction mode performs or understands a culture better or worse compared to a treatment group that is using a new mode of interaction, we have to make sure that the two modes of interaction do not differ greatly in cognitive loading. We must also ensure that the second group is not getting the same information twice. For example, Kavakli et al (2004), forgot to mention this effect in their interesting paper comparing learning history when playing a computer game to reading a text.

Fourthly, if we wish to understand how different interactive elements affect task performance, we may wish to have two or more groups, one being a control and the other or others using other modes of interactivity. However, we cannot then find out if a certain world-mode (a particular virtual environment with a particular mode of interactivity) is preferable to the same environment with a different mode

of interactivity.

Scientific experiments may use a Control Factor or a Factorial Analysis. In a virtual environment, it can be very difficult to articulate and separate the control factors. The uncontrollable factors may not be foreseen or be easily articulated.

In order to ascertain audience preference, we would need the audience groups to each experience the different world modes, and then evaluate them using factorial design methods (Table 13).

Table 13: Factorial Design for Two Groups

←Compare task performance across interactivity modes→

Compare user preference over 2 sessions	VE + Interactivity Mode 1 (i.e. Observation)	VE + Interactivity Mode 2 (i.e. Instruction)
Session 1	Group 1	Group 2
Session 2	Group 2	Group 1

Table 13 shows two different types of interaction being evaluated for the same environment. In session 1, Group 1 may be considered the control group, as observation mode is the typical default mode for virtual heritage projects.

However, we require two sessions so each group can experience both forms of interaction in order for them to tell us which interaction mode they prefer. We would now need to consider the ordering effect (the order of the sessions may affect the ability of the group to perform tasks and it may affect their critical appreciation of the interaction mode). It would now be even more important to ensure that people of different related abilities, preferences and experience are equally divided amongst the two groups (Table 14).

If we required more than two types of interactivity to be evaluated in terms of both task performance and user preference, we would need to have three or more sessions so each group would experience (and thus be able to compare) all the interaction modes.

Table 14: Factorial Design for Three Groups

←Compare task performance across interactivity modes→

Compare user preference over 3 sessions	VE + Interactivity Mode 1 (i.e. Observation)	VE + Interactivity Mode 2 (i.e. Instruction)	VE + Interactivity Mode 3 (i.e. Game-Style Instruction)
Session 1	Group 1	Group 2	Group 3
Session 2	Group 2	Group 3	Group 1
Session 3	Group 2	Group 1	Group 2

Fifthly, we may wish to compare different types of interactivity to a virtual heritage environment, but different contexts in the same environment may require different forms of interactivity. Different forms of learning and different traditional ways of

navigating environments or manipulating artefacts may require particular forms of interaction.

For example, interaction appropriate to the cultural learning of a monk in a monastery may not apply to the learning in the farms that feed the monastery. In the former, one learns by instruction, while in the latter one may learn by trial and error, or by observation. The environment may dictate a specific type of interaction, or a specific combination of degrees or even kinds of interaction.

The specificity of certain forms of historical interaction may impede the creation of general design guidelines, and it may present problems to the evaluation of cultural learning across a large virtual heritage project. This could mean, for example, that Table 14 would become even more complicated.

Hence, although there are many interesting and novel ways of evaluating virtual environments, there are a host of contextual issues, especially in terms of cultural learning, that bedevil testing this area. We have the problem of defining cultural learning, and ensuring this definition could produce clear and verifiable outcomes.

Even if we have clear outcomes that can be tested with small statistical samples, we must also ensure that the testing is as close as possible to real world use. Yet here in this emerging field the research literature is sparse, and comparisons with equivalent products and media are problematic. We must also attempt not to bore the test audience or cause cognitive overloading that may confound the results. The next chapter will outline an experimental design created to address these concerns.

9.1 Design Problem

9.1.1 Research into Cultural Presence via Interaction

The last chapter on evaluation listed various issues such as the problems of defining cultural understanding and learning, contextual appropriateness, and a reasonable sample size. Given those problems, how can we test the effect of interaction on cultural learning in virtual environments?

The research question motivating this study is the role of different modes of interaction affecting user engagement and learning in a virtual heritage environment. There is arguably a gap between environments built for evaluation and environments with specific content designed for end-users (Mosaker, 2001; Gillings, 2002; Roussou and Drettakis, 2003; Champion and Sekiguichi, 2004).

Turner et al (2005) have written that the surprising lack of contextual evaluation of virtual and in particular virtual heritage and archaeological environments indicates that we lack information on how to best transmit cultural understanding via digital media. Roussou and Drettakis (2003, pp. 46-57) suggested a reason for this, that there has often been an over-reliance on visual realism:

In some cases, the advancement of tools and techniques for achieving greater visual realism has distracted from the development of other directions that enhance a virtual experience, such as interactivity, sound or touch...we argue that it is important to enhance the perception of realism, achieved both through photorealistic and non-photorealistic visualisation approaches, with interactivity.

Perhaps one reason why we lack design guidelines and prescriptive theory for resolving this issue is the confusion between cultural and social presence mentioned earlier. Other possible reasons include the complexity of environmental study, the relatively recent development of widespread virtual environment technology, the large amounts of industry and research money that is tied into the success (and thus status) of the project, and logistics. Common example of logistics as limiting factors include lack of access to a suitably large test sample of the intended audience, and the limited time and resources available for full scale changes resulting from evaluations.

These factors prevent many researchers from studying different versions of the same project. Hence, it is desirable to test different forms of interaction as it affects

cultural understanding and user engagement for we lack this type of information, and it may serve as a testbed to inspire further ideas and design experiments.

I have argued in Chapter 6 that some of the best examples of engaging interaction are in computer games, not in virtual heritage environments. Game design, theories of 'place' and presence may thus improve contextual interaction and therefore engagement. However, if we use design elements of games to increase engagement this might adversely affect the user's notion of authenticity of the historical reconstruction.

Hence, we should also try to evaluate a sense of authenticity when using game-style interaction. Authenticity is problematic: it could be used to mean fidelity to historical sources, to archaeological theories, to material remains, or to the original inhabitants' perceptions and beliefs regarding their own environment.

Nonetheless, games seem to be successful in large part due to their increased interactivity achieved through the design features and place-making elements that was mentioned earlier. That was the hypothesis that virtual environments with game-style interaction will allow for greater engagement and a more culturally immersive learning environment, with some caveats already discussed and expanded on in the conclusion.

As we have seen in the preceding chapters, virtual environments often lack techniques for evaluating the extent to which they achieved their design goals. An experiment that uses different types of evaluation may also help in working out which methods best define effective cultural learning in a virtual environment.

9.2 Projected Solution

9.2.1 Aims of Experimental Design

The primary outcome aimed for is to understand the effect of interaction on cultural understanding acquired, and the sense of cultural presence.

A proposed secondary outcome is that designers and researchers of virtual environment can also use some of the evaluation methods (if successful), as well as interactive mechanisms for the evaluation of user engagement without simultaneously interrupting the user's feeling of engagement. Unencumbered by the demands and restrictions of commercial projects, the consistency and clarity of results can be compared against evaluation methods in order to draw some observations about the appropriateness of the methods chosen.

9.2.2 Chosen Method

This project tested cultural learning through various interaction modes. Test subjects from three clear 'interest streams' (three groups consisting of archaeology students, 3D visualisation or heritage experts, and travellers) were asked to experience Palenqué, an ancient Mayan site via Adobe Atmosphere, an online 3D virtual environment. Via three subgroups they interacted with three subsets of Palenqué (the Palace, the Cross Precinct, and the Temple of Inscriptions) via observation, social instruction (inworld scripted agents), and active participation (manipulating objects).

Prior to the full test experience a small focus group of domain experts were asked to undertake a cognitive walkthrough and give advice on improving the site for less experienced virtual environment users. For the full experiment, it was decided to record the domain knowledge of the users in terms of their age group and gender. Other data recorded includes how well they know the real world site, their experience of using computers, the Internet, 3D computer games, and CAD.

In the experimental design described in this chapter, user interaction was stored and evaluated against questionnaires and task performance to determine the most preferred interactive mode. Participants ranked the worlds (a virtual environment with a specific mode of interactivity) against each other. The participants were not asked to grade the worlds against a Likert scale, as it is difficult to calibrate Likert ratings.

During their time in the 'worlds', a database was used to track performance times and task completion rates. This data was automatically tracked and sent from the online virtual environment to the database. Each archaeological 'world' was of equal duration and was followed by a short questionnaire. There were questions asked at the end of the overall evaluation to test what people noticed and to see whether indirect evaluation may give accurate results as to user preference and task performance.

9.2.3 Significance

Embedded and embodied interaction may afford more cultural significance of a place. Interaction in a hermeneutically enriched environment will probably require more time for each participant, and so it is not dealt with in this experiment (most participants could only spare an hour in total).

The data gathered from user evaluations will ideally suggest answers to the following questions. Which varying modes of interactivity (constraints and affordances) add most to engagement in a virtual tourism environment and to a

'sense of place'? Is this indicated by the data collected by the interactive elements themselves or by the questionnaire? Is it possible for wide segments of an audience to be engaged and educated at the same time by interactions in a virtual archaeology project? Alternatively, must we leave genuine engagement to the realm of games?

Finally, did the users most enjoy finding and clicking on information, questioning inworld avatars or manipulating and moving objects to get through tricky passages? Did this allow them to gain a culturally embedded new world-view? Such results may help us determine which types of interaction add most to engagement in a virtual tourism environment and best afford a sense of cultural presence.

9.3 Experimental Component Selection

9.3.1 Site Selection

We can create a virtual environment case study in order to evaluate the relative success or failure of the above features. The site chosen is a Mayan temple-city that can appropriately use the above features in order to test user engagement.

I have selected Mayan culture for its unique cultural beliefs (such as prayer based on bloodletting, ballgame-creation myth, extensive trade, deliberate cranial deformation, as well as a belief in communication between rulers and ancestors via 'sky-snakes').

Buildings were of extreme importance to the Mayans, they were living sources of energy, and offerings to them appeased the gods, necessary for the growth of maize, the primary crop (Schele and Mathews, 1998; Foster, 2002; Taube, 1983).

Mayans layered their buildings on top of each other in order to augment their 'spirit energy' and each of the four directions required specific offerings. They were memory palaces that the priests kept perfectly preserved for hundreds of years. New layers of buildings were built on top of older ones, as the Mayans attempted to augment the sacred 'energy' of the ancestors to whom the buildings commemorated. Each of the four directions had special significance, as did the cenotes, the extremely deep wells to which the Mayans threw offerings, and which were sacred paths to the underworld and to hell.

The Mayans believed in three levels of existence, the sky, the earth and the underworld. Rites involving smoke, sacrificial blood, and offerings of food and artefacts were to thank the Gods for continual existence. Some artefacts were seen as magical aids that could help the spirits of the ruling class travel through portals

to the other planes of existence. 'Cenotes' (wells) and rivers were also symbolic links to the underworld, and many items of worship have been found there.

Far smaller in physical stature to modern people, the Mayans did not have the use of the wheel, the arch, or the horse. Yet they had an extensive knowledge of astronomy, intricate calendar systems, and a highly developed glyphic language used in conjunction with books, paintings, and sculptures (Figure 6: photo taken by author).



Figure 6: Palenqué Wall Carving

Today there are millions of Mayans still speaking the ancestral language, but they cannot read it. Their traditions have been infused to some extent with that of the Spanish, and all but a few of their books have been burnt. Yet even today, many still follow the dedication of offerings to buildings and follow the ancient ceremony 'Day of the Dead'.

In order to evaluate the various interactive elements as described above, the Mayan city Palenqué, in Chiapas, Mexico, was chosen. Palenqué (or Lakam-Ha in Mayan) is well documented, where the Mayan language was first decoded by archaeologists, and set in a spectacular landscape (Barnhart, 1998, 1999).

Although not as famous as say Tikal or Chichen Itza, it is not overly large and can be explored in a day or less on foot.

Palenqué was most prominent during the Classical period of Mayan civilization, and three of its temples hold three tablets to three different gods, as recorded in the

Popol Vuh, a Mayan story of creation. Palenqué was the site where archaeologists made a major advance in understanding the complex Mayan written language (Schele and Mathews, 1998; Foster, 2002).

The condition of inscriptions and setting of Palenqué, with its mountainous backdrop, wide-span temples, and collection of tablets, tombs and rivers, have made it a popular tourist destination. The early morning fog can be so strong that some archaeologists believe Palenqué was created to resemble the Mayan mythical origin of the current world, magical mountains that took form out of the primeval sea (Reilly, 1989).

Mayan tombs also had pipes constructed that linked the dead ruler in his or her tomb to the living world above (Schele and Mathews 1998). The Mayans believed that the rulers had magical umbilical cords that connected them to the gods in the sky, and constructed their buildings so that certain events - such as the equinox - were framed by the outline of specific buildings (Spero, 1986). For example, twice a year, the sky appears similar to the Mayan depiction of the 'Flowering Tree' that connects sky, the earth, gods (Schele and Villela, 2001), and their ancestors (when viewed east from the Temple of the Cross).

The three tablets of the major temples, plus the sarcophagus found in the tomb of Hanab Pakal the Great, in the Temple of Inscriptions, all stress the relation of heavenly bodies to the ascension of Kings, and to the importance of maize.

As the Palenqué rulers suffered a break in paternal lineage, their temples emphasized the rulers' right to lead by recording creation myths of the gods and linking them to divine properties of the rulers. As was the tradition with other Mayan cities, Palenqué's buildings were consecrated with human sacrifice (usually war captives), the ball court commemorated both trade and sacrifice, and slaves were found in the burial chambers of the kings (Kremer and Uc, 1993; Grube 1993).

9.3.2 Significant Cultural Features of Palenqué

Palenqué is grouped by archaeologists into a series of building areas. Three of the most famous buildings areas are the Temple of Inscriptions (which also contains an underground tomb with sarcophagus, the Palace (which is really a group of buildings constructed over 200 years over a common substructure), and the three temples of the Cross Precinct (the Temple of the Cross, the Foliated Cross, and the Temple of the Sun, known to archaeologists as the Cross Group).

Due to the size of the site, the amount of artwork found at each group and the limitations of the selected modelling and rendering application, it was decided to

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separate the environment into three versions.

Hence, three versions of Palenqué were built; all have the three groups along with terrain created from GIS data, but at different levels of completeness and lighting. For example, the Temple of Inscriptions environment has a dynamically lit Temple of Inscriptions, along with its related tablets, but the Palace building and the Cross Precinct in the Temple of Inscriptions environment do not have dynamic lighting, large textures, or their associated artwork. The Palace environment has only the Palace building dynamically lit, and the Cross Precinct environment has only the Cross Precinct temples dynamically lit. Invisible boxes surround the key groups of buildings in each environment to ensure the visitors do not stray too far.

I also attempted to emphasise key points of the site, but I needed to divide the content as appropriately and evenly as possible between the three virtual environments. This attention to the content is expressed in Table 15.

Table 15: Significant Features of Palenqué

Significant Features of Palenqué	Environment 1	Environment 2	Environment 3
Content Items	Inscriptions	Palace	Cross Precinct
Aesthetics (bloodletting, cranial adjustment, cross-eyed, height, colour)	√	√	√
Division of sky land and underworld	√	√	√
Mythic nature and power of animals	√	√	√
Origins of humans			√
Relation between stars –calendar-farming		√	
Relationship between Gods and Rulers	√	√	√
Relation between hierarchy of artefacts (buildings burials and books) and life force	√	√	√
<i>Vast trade routes were used (for trading copal, feathers, salt, beans, obsidian and jade).</i>			
The Mayans developed advanced technologies, water (cenotes), pipes, cocoa, alcohol, mirrors, and golden section.		√	
Social hierarchy: Kings lords day-keepers artists warriors traders farmers slaves.	√	√	√
There was a complex social relation to other tribes and to the past and future.		√	√
Content items mentioned in total:	6	9	8

The italics indicate that I was not able to include content on trade routes etcetera in the six questions testing contextual cultural understanding per environment. Due to the short testing time, most content was highly condensed, and the gorier features of Mayan culture were not included (as they would have required further clearance from the University of Melbourne Ethics committee).

9.3.3 Test Software

Software was tested and one product was chosen for the experiment, Adobe Atmosphere. Atmosphere allowed for chat-enabled internet-based three-dimensional worlds. Using JavaScript and a proprietary XML file format, Atmosphere could also import CAD-generated files.

It could also incorporate Flash-based textures, Windows Media (streaming media), and dynamic scripted effects such as collision, a physics engine, position-based sound, database integration, particles, and key-events, as well as button-driven interaction. This programme could also create native primitives, which offered increased frame rate speed, and improved dynamic lighting over imported models.

Various projects have already used Atmosphere for virtual archaeology projects (Stonehenge, lighthouse of Alexander, Landskrona Cathedral, the Great Pyramid of Cairo, Tikal, and Tenochtitlán). However, most of these environments have been designed as a three-dimensional gallery. They were typically not used with advanced scripting techniques for increased interaction between artefacts, avatars and the environment.

9.3.4 Projected Structure of Experimental Design



Figure 7: Groups A and B Interaction-Activity Observation and Instruction

I attempted to test whether I could find a link between interaction and cultural understanding by modelling and scripting a virtual heritage project with three different types of interaction. These 'interaction modes' were based on the schematic description of how we acquire cultural understanding (Figure 7).

I will refer to the different types of interaction as 'interaction modes', where users are to Observe, be Instructed (by scripted agents, also known as 'bots'), or Act (manipulate objects in order to accomplish tasks).

The testing involved two stages; the second stage involved three groups of participants. The first stage was a pre-test cognitive walk through by domain experts who offer advice on the questionnaire, content and interface.

In the second stage, three groups of users entered three different virtual

reconstructions of Palenqué. The second stage was user testing of three different 'worlds'. A world is here defined as a virtual environment with a specific type of interactivity. Since there were three virtual environments and three interaction modes, there were a maximum of nine possible archaeological worlds (digital reconstructions of Palenqué).

The first world was the Temple of Inscriptions along with an 'activity' interaction mode, which required the participant to move objects out of the way and to navigate the avatar into specific positions in order to be teleported to the next environment.

Users navigated the second world, with the Palace environment, and an 'observational' interaction mode, by clicking on objects. The goal was to find all such artefacts and read the related information, within nine minutes.

The third world was the Cross Precinct environment with an 'instructional' interaction mode. It had clickable objects along with agents (chatbots) that could ask and remember simple dialogue. The task was to gain knowledge through questioning the avatars.

Hence, the participants were required to interact with the virtual environments as

- Observers, who find and click on objects in order to retrieve information.
- Curious (or inquiring) travellers supported by social encounters with others (agent-scripted avatars.)
- Active participants (they must physically manipulate the environment to achieve their goals).

In order to test the potential confounding effect of environment on understanding and task performance, I also tested another group using the same environments, but I swapped the interaction modes around.

9.3.5 Projected Test Audience

I envisaged the users to be adult, PC-application literate, English-speaking and have no extensive site knowledge or knowledge of the culture of the modelled environment. Demographic backgrounds may have some influence on the results.

Hence, it was deemed useful to evaluate three types of users. Group A was to consist of archaeology students; Group B was to be historians and designers who have experience with three-dimensional digital environments; and experienced travellers that are au fait with information technology (Lonely Planet employees) made up Group C.

9.3.6 Sequence of Audience Participation

In order to reduce the 'sequence' effect, whereby the first world experienced may produce different results to the next two worlds encountered, each two participants entered worlds in a different sequence. This ensured, for example, that only a third of people entered the Temple of Inscriptions as their first world (Table 16).

Table 16: Sequencing User Testing of Archaeological Environments

Subgroups	First Environment	Second Environment	Third Environment
1	1-Temple of Inscriptions	2- Palace	3- Cross Precinct
2	3- Cross Precinct	1-Temple of Inscriptions	2- Palace
3	2- Palace	3- Cross Precinct	1-Temple of Inscriptions
4	1-Temple of Inscriptions	3- Cross Precinct	2- Palace
5	3- Cross Precinct	2- Palace	1-Temple of Inscriptions
6	2- Palace	1-Temple of Inscriptions	3- Cross Precinct

9.3.7 Evaluation Factors of Experimental Design

In the evaluation, participants were asked to complete certain tasks within a set time limit of nine minutes. At the end of nine minutes, they were asked to perform tasks (for three minutes) in an imaginative environment. Then they were asked to record answers to a multi-choice questionnaire, with six questions for each of the three environments. At the end of the experiment, they were asked to rank the worlds against each other, to answer questions on generic environmental details, and to guess the relative frame rate speeds of the three archaeological environments.

The aggregate levels of engagement of the observation mode, instruction mode and activity mode environments were assessed against demographic features of the audience. These included age, gender, experience of three-dimensional digital media, archaeological knowledge, PC game knowledge, and travel.

The control factors, the independent variables, were principally the three virtual environments, and the three 'modes' of interactivity, observation, instruction, and activity (Table 17).

Three types of interactivity, three audience groups, and the novelty of the technology, necessitated that the experimental objectives were best evaluated by factorial design statistics. Since a variety of evaluation methods were employed, there was also a need for qualitative judgements based on observations of participant responses when part of the design experiment.

Possible confounding factors included the disparity in sample size, background environmental details (computing power etcetera), speed of the Internet connection, and background experience not indicated by the questions. There could

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also be content differences between the three environments, or interaction modes may favour (be more suitable for) one environment over another.

Table 17: Evaluation Factors of Experimental Design

Experimental Variables	Case Study	Factors
Independent Variables: The 'Worlds'	Virtual Environment	The Temple of Inscriptions (a large temple with a hidden underground tomb reached by stairs).
		The Palace (a very large substructure supporting a dozen buildings).
		The Cross Precinct (three small temples).
	Interaction mode	Observation: Find artwork, click on artwork to find information on it.
		Activity: Push away objects and squeeze through tight spaces in order to reach goal.
		Instruction: Listen to the agents (bots) and click on artwork.
Dependent Variable	Cultural Awareness	Multi-choice performance.
		Task performance.
		Subjective ranking of worlds via Cultural Presence Factors.
Moderator Variables	Demographic factors	PC experience, age, gender, background profile, related travel experience.
	FPS	Frame rate of environment.
	Time passed	How quickly the time in the environment seemed to pass by.

9.4 Test Worlds Created

9.4.1 Warmup

The first environment every participant in every group visited was the 'Warmup' environment (Figure 8). The participants were given three minutes to familiarise themselves with the interface buttons, the chat box (which supplies text information), and clickable objects (which on being clicked pop up scrollable objects).

At the top of the webpage was a standard tool interface that allowed people to change their avatar. They could also display time taken so far, or click a button labelled 'home' to teleport them back to their starting position (in case they get lost or fall off the edge of a world or object). Another button displayed the distance to the next goal, while 'view goal' oriented them (their camera and their avatar) to the next goal they need to reach for.

The 'information' button popped up a webpage containing navigation instructions (such as how to move forward or move the camera independently of the avatar). The button 'reduce glare' did as it suggests (when there was glare in the environment), likewise for 'reduce fog', (fog was used as a substitute for levels of detail, and coloured fog was programmed to create a sense of day changing to

night).

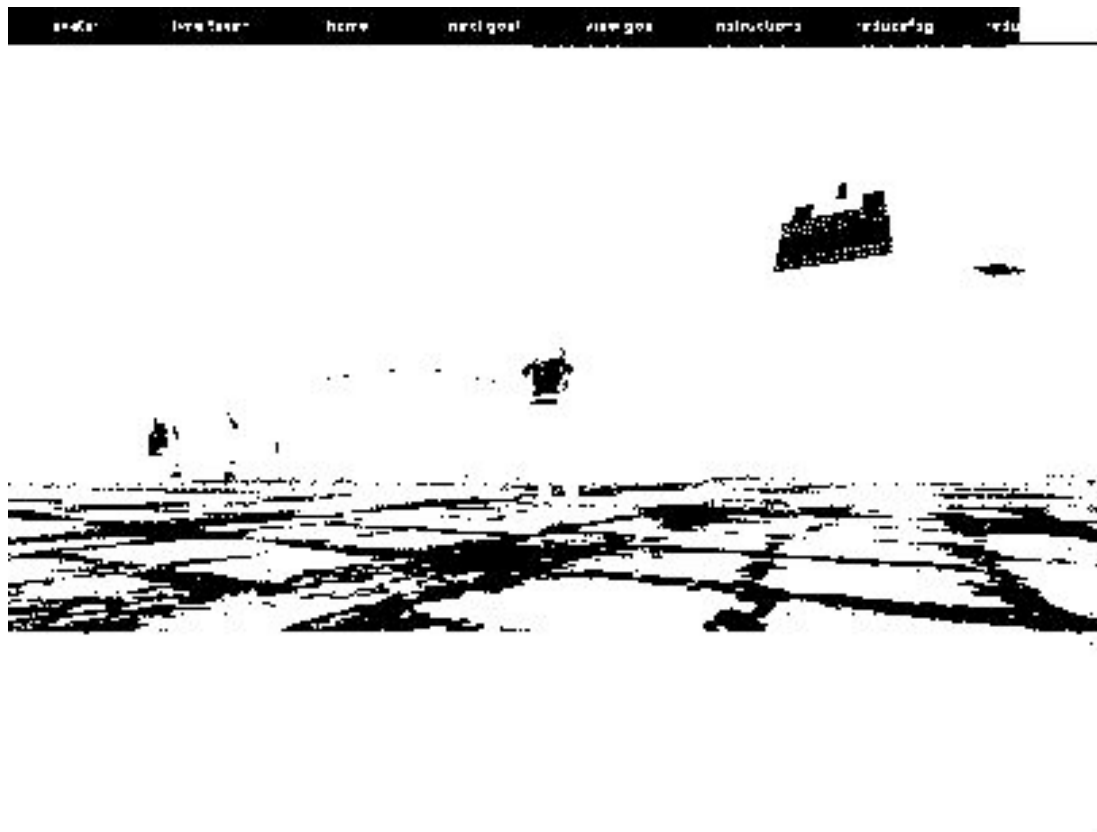


Figure 8: Warm-up World-Teotihuacán (All Groups)

9.4.2 Archaeological Environments for Groups A and B:

The first mode was action based, and the participants had to push back slabs to find the hidden tomb (this was actually what happened in the discovery of the Tomb of Pakal under the Temple of Inscriptions). If they managed to push back the sarcophagus lid of Pakal when they reached the tomb, a portal appeared that took them to a reconstruction of Palenqué's Ballcourt. The Mayan Ballcourt symbolised war, life and death, the growth of maize, and the victory of the Mayan ancestors over the Lords of the Underworld, Xibalba (Taube, 1983).

Several affordances, proxemic music, glowing lights every twenty seconds, and buttons would orient them to the next goal and tell them how far away they were. Photographs of real people available via the Lonely Planet Images database were mapped onto the face of each avatar. They were also allowed to fly since the steps were often huge and the eight (seven tested and one warm-up) environments were very large for a one-hour experiment. Only the action-based phase (Figure 9) had serious constraints; that is, manipulation skills were required to move the giant slabs that hid the secret passages.

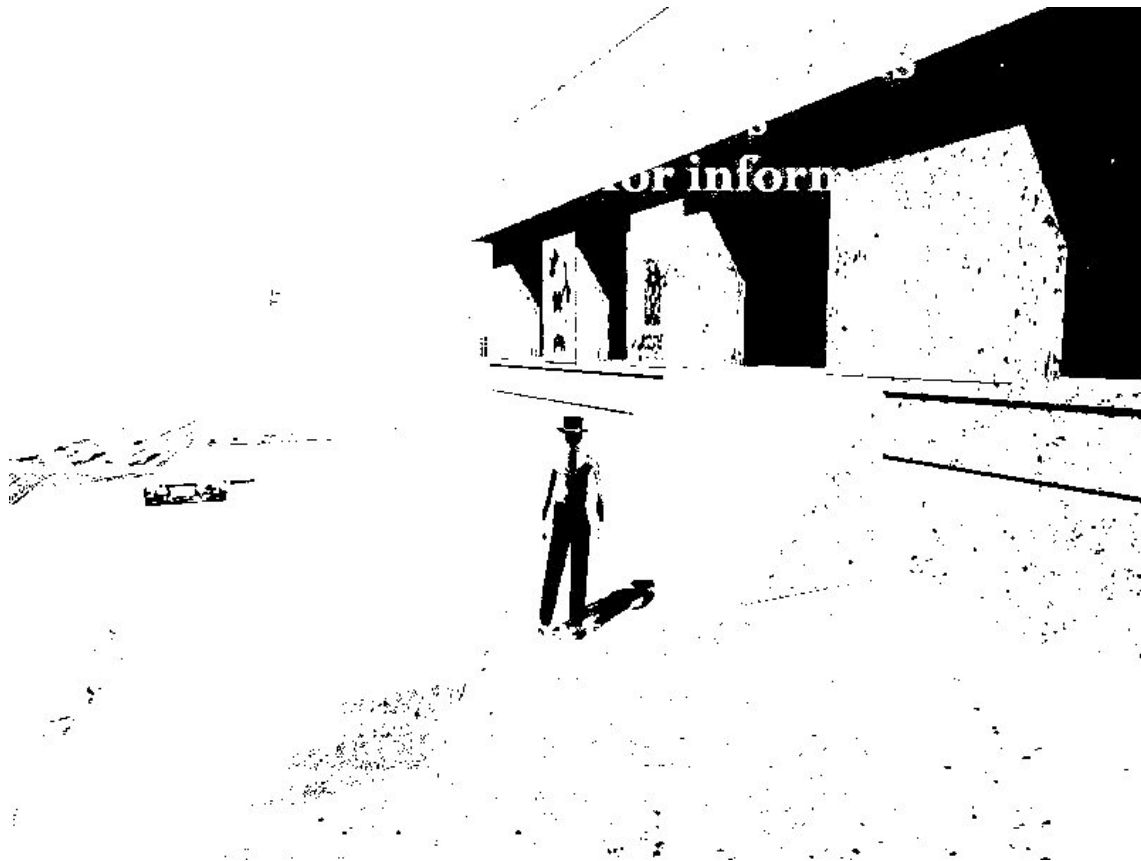


Figure 9: Groups A and B: Temple Of Inscriptions-Activity Mode

The second interaction mode was observation based only, and participants were asked to find artefacts located in the large and navigationally confusing Palace (Figure 10).



Figure 10: Groups A and B: The Palace-Observation Mode

In the third mode, the three major temples of the Cross Precinct had scripted guides, representing a Mexican tour guide, King Pakal, and his son. The guides' movements and speech were proximity-based, and they got angry or fell over if participants ran into them (Figure 11).

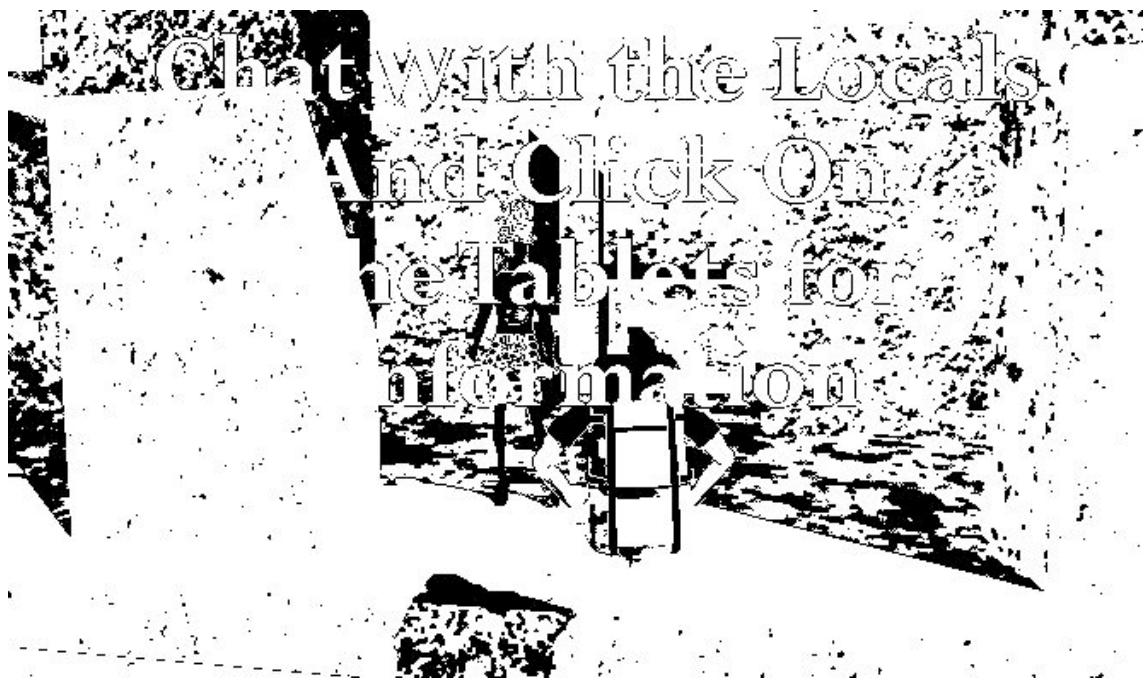


Figure 11: Groups A and B: Cross Precinct-Conversation Mode

The goal was also to click and read information relating to the giant inscripted tablets in each of the Temples. At the end of the experiment, people were asked to answer six questions for each interaction mode, to check what they had learnt and to see if they were able to extrapolate information from what they had seen.

9.4.3 Archaeological Environments for Group C



Figure 12: Group C Interaction-Observation Instruction and Observation

For Group C (to be covered in more detail in section 9.5.5), the interaction modes were swapped around, the Cross Precinct no longer had guides, now it was observation (find point and click) only. The Palace now had guides, and the Temple of Inscriptions was no longer activity based but observation based (find point and click). For a tabular explanation, please refer to Table 21.

9.4.4 Imaginative Environments



Figure 13: Milpas-Tourist avatar

I also created four more imaginative and less authentic 'worlds' based on the cultural perspectives of the ancient Mayans in Palenqué, Mexico. As part of the evaluation, participants were asked to rank the imaginative worlds against the archaeological worlds in terms of a range of presence criteria.

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In the Mayan Village world, users could select an avatar (a three dimensional representation of themselves) that was either one of four western style backpacking characters (Figure 13), or an avatar in local Mayan dress (Figure 14). Photographs of real people available via the Lonely Planet Images database were mapped onto the face of the avatars. The Mayan avatars were also sized appropriately (less than five feet tall) and only by changing into that smaller avatar were participants able to explore the interior of the Mayan huts. The aim was to find the other participant by orientating themselves against large Mayan carvings in the jungle.



Figure 14: Milpas-Native avatar

They were then to find the village using the interface guides and the sound of music. If they walked straight into trees, their avatar slowed down and cried out in pain. Which objects they found and how quickly they found them was also automatically recorded. At the end of the entire evaluation, the participants were asked the relative sizing of the avatars.



Figure 15: Primal Mountain

In the Mayan 'Primal Mountain' World, fog was used to convey a mythical setting and just as in the archaeological environments, glare was used at regular intervals to indicate where spiritually valuable artefacts were located (Figure 15). They were asked to find the beginning of the world (the Mayan sacred Sky-Tree), and click on it for information.

They were then asked to find any other people (there were two Mayan paddler gods paddling around the mountain). They were also asked if they noticed the mountain they were on was actually a giant crocodile (the Mayans believed the world was created from a crack in the back of a caiman or turtle).



Figure 16: Cave (Cenote) world

In the Mayan Cave world, when the avatar walks into the water, they automatically start swimming under water, blue fog appears and the sound of bubbling water drowns out the ambient Mayan music (Figure 16). If the participant does not keep

pressing the forward arrow, they slowly ascend back to the surface of the water. By finding, collecting and then dropping artefacts at a hidden shrine, a Mayan sky-snake appears and so does a portal that takes them back to the start.

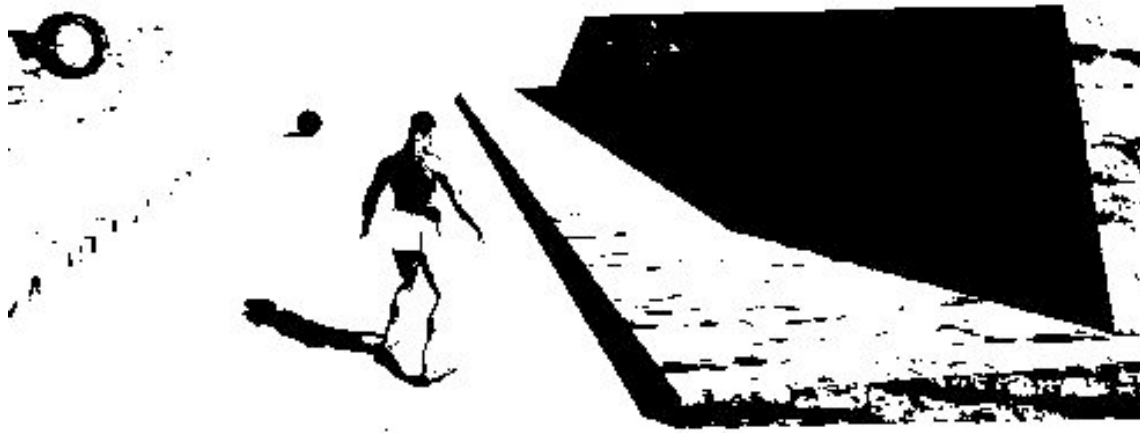


Figure 17: Mayan Ball court world

In the Mayan Ballcourt world, each participant turned into a Mayan ball player, and each was asked to try to get the rubber ball to touch the hoop (Figure 17). When approaching the ball they could trigger a kicking motion by tapping a certain key. Distance from the ball was inversely proportional to the power of the kick. If they managed to kick the ball into the hoop, thunder and lighting were triggered. If the ball fell off the edge of the simple world, it would automatically be recreated in the middle of the Ballcourt.

9.5 Evaluation Chosen

9.5.1 Cognitive Walk Through

Before the virtual environments were finished, three domain experts (an archaeologist who had used the application to create a digital reconstruction of a classical Greek villa, a 3D visualisation expert, and a virtual heritage designer) suggested refinements to the navigation and interaction. An archaeology lecturer (the teacher of the students evaluated as Group A), also provided feedback on the multichoice questions asked concerning Mayan culture.

The visualisation expert requested more concentration on multimodal feedback (which was achieved), and better keyboard mapping for navigation control (which could not be easily achieved in the software used). He also suggested the manipulation tasks in the Cave (Mayan cenote) might be too hard for novice users

(and to some extent he was proven right).

9.5.2 Demographics

The demographic data collected was of age group, gender, literary knowledge of Mesoamerican archaeology and culture, PC Internet and PC game experience, and travel knowledge of the region (Table 18).

Table 18: Test Audience Demographics

Age	Pc experience	Travel experience of South /Central America
15-25	Play 3D computer games.	Been many times.
25-35	Use drawing/3D programs.	Have visited.
35-55	Use it for word processing.	Have read about the culture.
Above 55	Hardly use at all.	Have not yet learnt much about it.

9.5.3 Actual Audience Groups Tested

Group A Evaluations were conducted using a first year archaeology class of forty-nine students, and for Group B, twenty-four more experienced participants who were either virtual environment designers or cultural historians with an interest in virtual heritage. For group C, ten IT-experienced people from Lonely Planet Publications (a travel publications company with a strong web-based presence), were tested (Table 19).

Table 19: Groups Tested

Group	Group A	Group B	Group C
Number in Group	47	24	10
Description of virtual environments	Archaeology students using prototype in class.	VR and cultural heritage experts evaluated 2 at a time.	IT experts from Lonely Planet evaluated 2-3 at a time.
Archaeological	Cross Precinct, Palace, and Inscriptions (9 minutes each).		
Imaginative	Village, Cave, Ballcourt, and Mountain (3 minutes each).		

Group A was a class of first-year archaeology students who were evaluated using the seven above environments, at the University of Melbourne, in computer lab settings of up to fifteen people. They were asked general questions on cultural knowledge acquired, and were tested on what they observed, asked to rank the worlds in terms of several 'presence-style' criteria, asked to judge which world had the fastest speed (frame-rate), and their in-world task performance was also recorded.

As part of the evaluation, the Group A participants were asked to rank the imaginative worlds against the archaeological worlds in terms of a range of 'presence' criteria. The Group A machines were slower than the ones used for Groups B and C. Group A was the only group to be evaluated in a classroom setting (and using speakers not headphones), and not all the participants completed the

questions. Due to these confounding factors, I did not statistically compare their results to Groups B and C. Instead, Group A results were used as a test of the worlds as a prototype, and as indicators of potential future research.

Group B consisted of 24 domain experts, cultural historians, archaeologists and designers of three-dimensional (especially virtual) environments with the same evaluation methods. They were evaluated in pairs, in a university computer lab using two fast machines with powerful graphic cards.

Group C were ten people from Lonely Planet. Due to the difficulty of getting all the participants to visit the university computer lab in a short span of time, the two machines used by Group B, plus an extra identically configured machine, were set up at the Lonely Planet computer training room. In terms of this experiment, the setting is not significantly different to the lab used to test Group B. Ideally Group C would consist of at least 12 people, but logistics made an enlarged sample size impossible.

9.5.4 Tasks Set in the Environments

The below table shows the objectives set to each participant for Groups A and B (Table 20). Once they completed the archaeological world tasks (worlds 1, 2, and 3), they were teleported to the related imaginative worlds (worlds 1a, 2a, and 3a), depending on the sequencing of the worlds.

Table 20: Palenqué Tasks for Groups A and B

No.	Environment	Objective of Environment (Groups A and B)
Warmup		
a	Teotihuacán	In 3 minutes learn how to use software
b	Milpas (village)	In 3 minutes discover / share /navigation
Archaeological and Imaginative Reconstructions of Palenqué		
1	Inscriptions (action)	In 9 minutes move slabs to descend to bottom of temple
1a	Mayan Ballcourt	In 3 minutes Action-play
2	Palace (observation)	In 9 minutes Find artefacts and click on them.
2b	Cave	In 3 minutes pick up and release artefacts
3	Cross Precinct (guides)	In 9 minutes find and listen to guides, then enter temple
3c	Primal sea-mountain	In 3 minutes discover the world tree; reach the paddler gods.

This pattern was repeated for Group C, except that the interaction modes of worlds 1, 2, and 3 were swapped around (as mentioned in the next section).

9.5.5 Sequence of Environments

Ideally, as mentioned above, there should be nine worlds, but it was found in the design of the environments, that not all three modes of interactivity were easily transferable across the three digital environments. While Instruction and

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Observation modes were easily transferable, Activity mode was ideal for the Temple of Inscriptions but not for the other two environments. This necessitated an abbreviated factorial design (Table 21).

Table 21: Environment Interaction for Groups A B and C

Environment	Group A and B interaction mode	Group C interaction mode
Inscriptions (9 minutes)	Activity	Observation
Palace (9 minutes)	Observation	Instruction
Cross Precinct (9 minutes)	Instruction	Observation
OVERALL	Compare A O and I interaction mode results for Group B	Compare O and I interaction mode results for Group C

While the first three worlds (for Groups A and B) were Inscriptions-Activity, the Palace-Observation, and the Cross Precinct-Instructions; the second set of worlds (for Group C) were Inscriptions-Observation, the Palace-Instruction, and the Cross Precinct-Observation.

For Groups A and B, the three environments each had their own mode of interaction. For Group C, the three environments had different interaction modes (i.e., they were swapped around). For group C, the aim was to swap the interaction styles while keeping the content as similar as possible. The main objective was to compare the Group C results to those of Group B to ensure that the different environments themselves were not causing the results to be skewed.

Table 22: Palenqué Environment Groups A B and C

No.	Group A (n=47)	Group B (n=24)	Group C (n=10)
Warmup			
a	Teotihuacán	Teotihuacán	Teotihuacán
b	Milpas (village)	Milpas (village)	Milpas (village)
Archaeological and Imaginative Reconstructions of Palenqué			
1	Inscriptions (action)	Inscriptions (action)	Inscriptions (observation)
1a	Mayan Ballcourt	Mayan Ballcourt	Mayan Ballcourt
2	Palace (observation)	Palace (observation)	Palace (guides)
2b	Cave	Cave	Cave
3	Cross Precinct (guides)	Cross Precinct (guides)	Cross Precinct (observation)
3c	Primal sea-mountain	Primal sea-mountain	Primal sea-mountain

In terms of the order, each group spent three minutes in the warm up environment (refer Table 22). Each group also spent three minutes in the imaginative worlds (their content did not change between groups). Each group also spent nine minutes in the three archaeological environments (Inscriptions, Palace and Cross Precinct). However, the order they experienced each archaeological world was staggered within each group to ensure that results were not dependent on the sequence of

the worlds experienced.

9.5.6 Questions

For the questions in full please refer to the appendices (Chapter 13: Appendices). A summary table of the questions is shown here (Table 23). All three groups were asked the below questions.

Table 23: Summary of Evaluation Questions

Evaluation	Content	Objective
Task performance	6 information objects to find per environment	Compare to understanding
Cultural Understanding (multichoice)	6 multichoice questions on the Temple of Inscriptions	Compare to preference, task performance and demographics.
	6 multichoice questions on the Palace.	
	6 multichoice questions on the Cross Precinct.	
Presence Survey (rank from 1 to 7)	Which did you find the most challenging to explore, find or change things?	Compare to demographics and task performance.
	Which was the most interesting to you?	Find personal preference in answers (A to D/E).
	Which seemed most interactive to you?	Rank the 3 archaeological and the 4 imaginative environments from 1 for highest (most, closest), and 7 for least close.
	Which did you feel most closely represented the way Mayans saw their own world?	
	Which most effectively seemed inhabited by real people?	
	Which felt most like you were in the presence of Mayan culture?	
Environmental Recall: did you notice? (multichoice)	Shadow?	Compare to demographics, to task performance and to understanding.
	Real people?	
	How tall were Mayans compared to modern western people?	
	How many real or computer scripted people were in the site?	
	In future, which would you like such environments for?	
Subjective Experience of Time Passing (rate 1-3)	In each environment, did time pass by quickest? (Write in descending order of apparent speed).	Compare to subjective preference and to demographics.
	Rank the environments (1 for fastest to 3 for slowest) for how slow they seemed to be for updating the screen.	

9.6 Statistical Methods Selected

For the experimental design, demographics data, tasks completed, questions answered correctly, ranking of 'worlds' against cultural presence criteria, memory of environmental details and perceived frame rate, as well as preferred use of virtual environments, were recorded. Due to the range of data recorded, various statistical methods were chosen.

9.6.1 Task Performance

The hypothesis advanced here is that adding game-style interaction to virtual heritage environments may increase participant interest, and their cultural understanding of the experience. Hence, adding and evaluating tasks for the participant to complete may help this goal, and we can evaluate the hypothesis using task completion rates.

In order to assess this hypothesis statistically, the null hypothesis is that task performance is not linked to understanding. To justify rejecting this null hypothesis, by using ANOVA it is hoped that we find a five percent or less (p is equal or less than 0.05) chance that task performance and understanding do not positively affect each other.

9.6.2 Understanding

The hypothesis advanced here is that adding game-style interaction to virtual heritage environments may increase participant interest, and make the experience more memorable. Hence, providing for different interaction modes, action-based, and non action-based, may help create a more memorable and enjoyable visitor experience.

We can assess the validity of this hypothesis by asking the participant to answer questions that test what they have learnt and are able to extrapolate about the virtual heritage environment they went to, in relation to the interaction mode (whether it was action-based or not action-based). At a secondary level, we can assess whether prior computer game and 3D design experience, affects understanding, by using a pre-questionnaire that records the participant's gaming and 3D design experience.

In order to assess this hypothesis statistically, the null hypothesis is that action-based interaction is not linked to understanding, and, secondly, that gaming and 3D design based experience does not statistically correlate with higher scores in the cultural understanding post-questionnaire. This null hypothesis is again testing using ANOVA.

The ANOVA method also allows us to test across shared interaction modes as they affect understanding as a dependent variable. We can also use this method to make pairwise comparisons across interaction modes. We can also combine the environment and the interaction mode as independent variable ('worlds') across the groups as they affect understanding as a dependent variable.

We also need to test that the sequence of worlds that participants visit (the Order they visit them in), does not affect understanding. To evaluate whether the

sequence is significant on understanding as a dependent variable, General Linear Model with estimated marginal means can be used to determine between-subjects effects.

9.6.3 Presence Survey (Ranking the Worlds)

The virtual environments coupled with their interaction mode were ranked against each other according to customised presence criteria. Preference testing is frequently conducted via Likert scales. A favourite evaluation method of many researchers, the Likert scales system was developed to test emotive responses, and requires experience on the part of the participants to apply them correctly. Slater and Steed (2000, p. 8) noted that while this can be addressed, subjective rating scales use scores that are ordinal, and should not be combined together to form summations. An online report on the assessment and evaluation of landscape aesthetics (The Macaulay Land Use Research Institute 2004, para. 59), suggests that Likert scales can be used for aesthetic assessment of landscapes, but that there should be examples that range across the entire scale of the assessment.

For example, a virtual environment experimental design by Hedman (2003), compared the navigation and usability preferences of six participants learning about conceptual modelling in an online ActiveWorlds environment with the responses of six others learning about the same topic using a conventional website. The evaluation appears to have used a Likert scale of agree, neutral, or disagree to collect the data and then added together what are actually ordinal and not interval scores.

In the case of cultural heritage, subjective ratings taken from the use of a Likert scale must be carefully used if they are to evaluate cultural presence in virtual heritage environments. For example, how does an evaluator ensure that a participant understands how cultural presence can be marked on a scale of one to five or one to seven? How can cultural presence be evaluated if the participant has nothing to compare the virtual environment to? If a participant was asked how 'Mayan' the virtual reconstruction seemed to be, they would need some frame of reference in order to gauge this.

For such use of the Likert method, it would be advisable for the participants to have the same referential background. Yet in this experimental design there are three groups, group A involves students, group B involves cultural heritage and visualisation experts, and group C involves information technology specialists that work for Lonely Planet. They may all have differing ideas of what constitutes Mayan culture and what qualifies as suitable educational content.

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Their domain knowledge was tested by using a Prequestionnaire, but there was not enough time to accurately determine their level of Mayan archaeological and anthropological knowledge, hence the ranking system and not Likert scales were used. Ranking the seven 'worlds' against each other according to criteria gives participants a comparative framework to work from, rather than getting them to evaluate this novel experience in terms of cultural knowledge of the real world context (Mayan archaeology) that they almost certainly did not possess, or, did possess at quite varying levels to each other.

Ranking was thus added together for each virtual environment and the specific interaction applied to it. Therefore, one third of group A experienced the same virtual environment and interaction mode. One third of group B shared the same virtual environment and interaction mode (eight people). One third of group C shared the same virtual environment and interaction mode.

If the demographic data allows us to consider group B and group C as people encountering a combination of the same environments and same interaction modes but as separate worlds (a world being a distinct environment with a specific type of interaction available to it), we can analyse the worlds as separate treatments (world 1, world 2, world 3 and so on). We can also separate the effect of interaction and environment on the ranking used by the participants.

The hypothesis advanced here is that adding game-style interaction to virtual heritage environments increases participant interest, and makes the experience more memorable. Hence, providing for different interaction modes, action-based, and non action-based, may help create a more memorable and enjoyable visitor experience.

We can assess the validity of this hypothesis by asking the participant to rank the virtual environments against each other, in relation to a series of contextually specific presence questionnaires. An expectation is that the more challenging virtual environments will be more interesting, and that more interactive environments will also rank more highly for interest, and for a feeling of cultural presence.

The null hypothesis for this section will be that there is no statistically significant relation between more interactive environments and environments that are perceived to have a higher sense of cultural presence.

The statistical method chosen to evaluate the ranking of the worlds in terms of presence criteria was a sign test (sometimes called a "binomial test"). This test was chosen as it is both very simple and very useful in comparing individual differences (Howell, 2001, p. 135).

For each possible pair of worlds, the sign test allows us to calculate the difference between the rankings, and the analysis considers how many of the differences are positive, i.e. how many of the comparisons ranked the first of the pair of worlds higher.

9.6.4 Environmental Recall

The hypothesis here is that people who scored higher in task performance and understanding, will remember more details when answering a post-questionnaire. A secondary hypothesis is that gaming and 3D design experience may also affect environmental recall. The null hypothesis is thus that there is no statistically significant relation between accurate environmental recall, task performance and understanding. Simple Linear Correlation (Pearson r) can be used as the statistical method to evaluate environmental recall against demographic data.

9.6.5 Perceived Frame-Rate

This section of the thesis deals with ranking the three virtual environments (1 for fastest to 3 for slowest) for how slow they seemed to be for updating the screen. Data on the perceived frame rate when evaluated against subjective ranking of worlds in terms of engagement may show us a statistically significant link between perceived frame rate and subjective engagement. That is, the faster the frame rate perceived, the more the user may be engaged in the world (does not notice lag, and on recall thinks the time passed quicker than it actually had).

The hypothesis is that the more noticeable and accurately ranked the frame-rate of the world; the less interested is the person in the environment. This can be compared against the Presence rankings. A secondary hypothesis is that people with gaming experience will be better at comparing frame-rate speeds, and that this may confound the first hypothesis. The null hypothesis will be that there is no statistically significant relation between inaccurate frame-rate estimation and engagement.

The statistical method chosen to evaluate perceived frame-rate against demographic data, performance and cultural understanding, was the ANOVA method for reasons already mentioned in the previous section.

9.7 Summary of Experimental Design

Ideally, the experiment was designed to indicate the effect of interaction modes and to a lesser extent the effect of demographic factors on task performance and cultural understanding in a virtual environment. It may be considered excessive to

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ask so many questions and use so many evaluation methods. However, not only are the results of interest, but also the relationship between the results as achieved by different evaluation methods.

As cultural presence is a vague and hitherto infrequent term (being conflated by many researchers as equivalent to social presence), a mismatch is possible between the tested extrapolated knowledge and the presence survey rankings of preferred worlds. Those results that matched more consistently may indicate which evaluation methods are better suited to evaluating a sense of cultural presence.

Unfortunately, due to their content specificity, the three interactive modes as control factors could not be evaluated across all three environments. This forced to me to evaluate each world (there were six different worlds as independent samples), and to compare observation mode across the three environments, and against the other two interaction modes, as a form of control. Therefore, if the environmental content was a confounding factor, I could still aim to achieve some statistically significant results.

Another problem that could arise was that the results (outcomes, or response variables), might not be clear due to a limited sample size. The impossibility of evaluating Group A in a controlled experiment and having a large enough sample size in Group C could confound some of the results.

I found Group A to have the largest range and intensity of uncontrollable factors that might affect the expected outcomes. These factors were variable and substandard computing performance, highly varying number of students in the class, incomplete questionnaire results, and interest of the class group. Despite being archaeology students, they expressed much less interest in the archaeological content than the other groups.

Therefore, in the next chapter for Group A, I only consider ranking of the worlds and environmental recall. Their machines were too slow and variable to consider and compare task performance against the other groups. The varying speed of the two or three machines used in Groups B and C may also vary slightly, but that is not expected to alter the results significantly. Frame rates of the environments were recorded and averaged to ensure variation is not too high.

One of the reasons the technology was chosen was due to its support by a major software company, with a reputation for intuitive interfaces and documentation. The documentation and support did not live up to this reputation, and in some cases, features were actually removed rather than added to and improved on. For example, early beta versions included a snapshot function, so that one could script automatic or user-driven screenshots. The experimental design could have used

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this feature for creating memento maps, but the feature was removed without notice.

In addition, despite being promoted for online communities, the chat-server was not supported, and difficult to implement in-house. The unreliability of the chat-server prevented the testing of social agency and hermeneutic inscription, as the customised interactive chat filter scripts and commands could not be relied on, (they depended on a chat-server).

In hindsight, the limitations of the technology chosen indicate that another product should have been used instead. Many of the promised or existing features were changed or removed, and the apparent ease of modelling and animation were apparent rather than real. The biggest hindrance though, was the lack of rendering power to display the full environment as a single entity and not as three environments. A smaller hindrance was the lack of documentation showing how to script interactive agents and chatbots to react to the participant avatars.

10.1 Introducing the Participating Groups

In the following results for all groups (A B and C), an environment will refer to the content of the virtual environment. Interaction mode will refer to the type of interactivity, Observation, Action or Instruction. A world will refer to a specific combination of archaeological environment plus interaction mode. The sequences in which the groups' participants experienced the archaeological worlds were staggered to avoid the order effect confounding the results.

However, unlike their three archaeological counterparts, when I refer to the four imaginative environments or the four imaginative worlds I mean exactly the same thing, for their interaction mode did not change. Every member of every group experienced exactly the same imaginative world/environment. All three groups participated in the same four 'imaginative' worlds (the Mayan Village, the Cave, the Primal Mountain, and the Ball court).

For Group A and Group B, the three archaeological worlds tested were Action-the Temple of Inscriptions, Observation-the Palace, Instruction-the Cross Precinct (Table 21). Group C experienced Observation-the Temple of Inscriptions, Instruction-the Palace, and Observation-the Cross Precinct. This adds up to a total of six archaeological worlds that were tested.

Various technical factors interfered with the speed of the computers used to test group A. Collated results were used from Group A for environmental recall, perceived frame-rate, and preferences for types of virtual environments, for comparison with Groups B and C (Table 24). Task performance and understanding (answers to the multichoice questions) were not recorded. Unlike participants from Group B and Group C, not all participants in Group A fully completed answering the evaluation, so Group A demographics will not be considered.

10.1.1 Group A

Useful results from evaluating Group A were qualitative observations rather than quantitative data. Despite having a useful sample size of 47 recorded student results for the three archaeological worlds (Table 24), several factors confounded Group A results. The computers were slow, the evaluation was in a classroom

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without headphones, and the students did not complete all the evaluation questions.

However, some observations can be made about user expectations. Students wanted to examine what was interactive, and whether they could personalise their avatars. Despite being first year students in archaeology with classroom work on Mayan archaeology, the majority of students were not very interested in examining Palenqué's Mayan artefacts. They wanted as much navigational flexibility as possible (such as flying), rather than contextually appropriate interaction. Roughly, a third of the first class wanted to know what they could destroy, which was a completely unexpected request.

10.1.2 Group B

Group B featured twenty four people with experience in virtual environment design or the social sciences and 3D environments (Table 21). They were evaluated two at a time in far more controlled conditions than group A. Each person was given a headphone set so that their audio experience would not affect the other participant. Each participant completed the entire evaluation.

10.1.3 Group C

Group C featured ten people who worked for Lonely Planet publications. The testing was all done in one day, on Lonely Planet premises in their training room, with machines used for Group B, plus an additional machine with the same specifications. Each participant completed the entire evaluation.

The interaction modes were swapped around from those used for Groups A and B (previously outlined in Table 21), but as discussed in the last chapter, it was not possible to add the action mode to another environment hence Action-Inscriptions became Observation-Inscriptions, Instruction-Palace became Observation-Palace, and Observation-Cross became Instruction-Cross. This swap was done so we could compare Action mode to Observation mode (on the Temple of Inscriptions), and compare as a factorial design the two interaction modes (Instruction and Observation), against the two environments (Palace and the Cross Precinct).

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10.1.4 Demographic data

Table 24: Demographic and Evaluation Data Recorded for All Groups

Demographic Results	Group A	Group B	Group C
Experience in			
visualisation/IT	0	11	0
heritage	0	3	0
graphic design	0	2	0
architecture	0	1	0
IT	0	0	9
GIS	0	7	1
<i>archaeology students</i>	47	0	0
<i>TOTAL respondents</i>	47	24	10
Age Group			
age group 15-25	13	7	5
age group 25-35	9	15	4
age group 35-55	2	2	1
age group above 55	1	0	0
<i>Total who answered the age group question</i>	25	24	10
Gender			
male	Not asked	18	10
female	Not asked	6	0
<i>Total who answered the gender question</i>	Not asked	22	10
Computer experience			
played 3D games	11	17	6
Use drawing/3D programs	22	21	6
Use it for word processing	4	23	9
hardly use PC at all	26	0	1
<i>Total who answered the pc experience section</i>	28	24	10
Travel experience			
Have not yet learnt much about it	10	2	4
Have read about the culture	18	1	4
Have visited	0	14	1
Been many times	0	7	1
<i>Total who answered the travel section</i>	28	24	10
Personal Preference			
A To socialise	3	1	1
B To explore (scientifically)	12	12	2
C To experience (aesthetically)	16	10	2
D Undecided	10	1	5
<i>Total who answered the VE preferences section</i>	41	24	10
<i>Total participants who handed in answers</i>	47	24	10

10.2 Task performance

This measure recorded how often participants managed to click on different information sources. For observation interaction mode, they just had to find the objects, for instruction, they also needed to get advice from the guides, for action, they had to move objects in order to get to the information and click on it. Results were interval data, with a value of 0 to 6 for each 'world' visited. The scores for the imaginative worlds were also recorded but not statistically evaluated as they did not directly relate to cultural understanding.

10.2.1 Group A task performance

Group A, task performance was not recorded, due to hardware difficulties, and students not completing each virtual environment and interaction mode.

10.2.2 Group B task performance

Out of a possible task performance score of 6.00 for each world, the twenty-four participants of Group B received a mean score of 3.88 for the Action-Inscriptions world, 2.67 for Observation-Palace world and 5.92 for the Instruction Cross Precinct world. Task performance did not seem to relate to understanding for Group B when analysed by world (Table 25). Although the Instruction-Cross Precinct world scored near perfect task completion scores, it was second in the multi-choice cultural understanding scores. In addition, although the Action-Inscriptions world was superior to Observation-Palace for task performance it scored considerably lower for the multi-choice cultural understanding.

Table 25: Group B Task Performance and Understanding

Group B (n=24)	Task performance mean	std	Understanding mean	std
Action-Inscriptions	3.88	1.45	1.42	1.14
Observation- Palace	2.67	1.24	2.67	1.09
Instruction-Cross	5.92	0.41	2.21	1.35

The result for task performance in the Instruction-Cross world was an almost perfect score (a mean of 5.92, a standard deviation, abbreviated in the table as std, of 0.41. Yet it was second behind Observation-Palace for understanding (Instruction-Cross had a mean of 2.21). Action-Inscriptions came second for task performance (a mean of 3.88) and third for understanding (a mean of 1.42). Clearly, in this experiment, task performance is not directly related to understanding or there are some confounding factors.

In addition, the correlation by subject between task performance and cultural understanding was not significant ($n=24$, $r = 0.25$, $p = 0.24$).

10.2.3 Group C Task Performance

Table 26: Group C Answers to Multichoice Questions

Group C (n=10)	Task performance mean	std	Understanding mean	std
Observation-Inscriptions	3.50	1.96	1.70	1.16
Instruction-Palace	2.70	1.49	1.60	1.35
Observation-Cross	6.00	0.00	2.00	1.33

Out of a possible task performance score of 6.00, the ten participants of Group C received a mean score of 3.50 for the Observation-Inscription, 2.70 for Instruction-Palace and 6.00 for Observation-Cross Precinct World. The last world is obviously easiest to navigate and complete the tasks (Table 26).

The Observation-Cross Precinct world had by far the best mean task performance (6.00, a perfect score) and the best mean score for understanding (a mean of 2.00). However, the experimental results do not clearly indicate that task performance is directly related to understanding; or there are some confounding factors.

Out of a possible score of 6.00, the mean for cultural understanding is 1.70 for Observation-Inscriptions, 1.60 for Instruction-Palace and 2.00 for Observation-Cross Precinct. Hence, Instruction-Palace scored the worst for task performance and the worst for cultural understanding.

Group B was slightly better at both understanding and task performance on average; compared to group C. Results were similar between groups except for understanding regards the Palace. With guides Instruction-Palace for Group C did markedly worse (mean was 1.60) than Observation-Palace for Group B (mean was 2.67). The only difference was that Group C had guides but Group B did not. It was completely unexpected that adding guides to a virtual environment would actually reduce understanding.

10.2.4 Age and Gender Factors for Groups B and C

If we consider the participants in groups B and C as one group (and the similar individual demographics and shared workstations indicate this is possible), we get 34 participants (n=34), and clear results on understanding and task performance as affected by the age group (Table 27).

The twelve people aged 15-25 scored an average of 1.78 for understanding and 4.33 for task performance. The nineteen people aged 25-35 scored 2.09 on average for understanding and 4.09 for task performance. The three people aged 35 and above scored 2.33 for understanding and 3.56 for task performance. Clearly, the younger the person the more tasks they were able to complete, but the older they

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were the better they scored in answering the questions on cultural information.

Table 27: Groups B and C Understanding and Task Performance (Age)

Age Group	15-25 years (n=12)		25-35 years (n=19)		35-55 years (n=3)	
	Mean	std	Mean	std	mean	std
understanding	1.78	0.81	2.09	0.88	2.33	0.58
performance	4.33	0.90	4.09	0.72	3.56	0.77

Table 28: Groups B and C Understanding and Task Performance (Gender)

Gender	Group B (n=24)	Group C (n=10)	Understanding	Task Performance
Female	6	0	1.28	4.39
Male	18	10	2.15	4.10
<i>Total who answered</i>	<i>24</i>	<i>10</i>	<i>34</i>	<i>34</i>

The effect of gender on task and understanding was more marked. The six females scored 1.28 for understanding and 4.39 for task performance, while the twenty eight males scored higher on understanding (2.15) and less for task performance (4.10). This was surprising, perhaps the females had better spatial hand-eye coordination or perhaps they followed the instructions more closely and did not wander around as much as the males.

It is not clear why their understanding (that is, the mean understanding of the females as a subgroup) was nearly half that of the males, but as there were only six of them; the sample size is not large enough to draw any strong conclusions.

The extent of their game experience did seem to have an effect on their understanding, and to a lesser extent, on their task performance. The eleven that did not play computer games scored 1.67 for understanding and 4.00 for task performance. The twenty three that did play games scored higher for understanding (2.16), and for task performance (4.22).

10.2.5 Other Demographic Factors for Group B

It was possible to run a statistical correlations test on the effects of task performance for Group B according to demographic factors (Table 29). There was found to be a nearly significant negative effect of travel experience over task performance ($n=24$, $r=-0.374$, significance $p= 0.072$). No statistical significance was found for PC game, CAD experience, or age in relation to task performance.

Results

Table 29: Group B Demographic Data and Task Performance

Group B (n=24) Task performance	Pearson Correlation	Significance (2-tailed)	std
PC Game Experience	-.120	.575	0.46
Age	-.177	.407	0.34
Understanding	.250	.238	1.14
Travel	-.374	.072	0.83
CAD experience	-.203	.341	0.34

There was also found to be a significant relation between PC game experience and age, ($n=24$, $r=.564$, $p=0.004$). However, this was not directly related to the research objectives (Table 30).

Table 30: Group B Age and PC Game Experience

Group B (n=24) Task performance	Pearson Correlation	Significance (2-tailed)	std
PC Game Experience	.564(**)	.004	0.46

**Correlation is significant at the 0.01 level (2-tailed).

10.2.6 The Sequence Effect on Task Performance for Groups B and C

Firstly, the order in which people visited the archaeological worlds affected both task and understanding results, but only for the first world that they entered. For example for Groups B and C combined, out of a maximum possible score of 6.0, the mean for understanding was 1.65 for first world entered, 2.29 for second world entered, and 2.06 for the third world entered.

Group (n=34) Sequence	Understanding (mean)	std	Task (Mean)	std
B & C First world entered	1.65	1.18	3.82	1.29
B & C Second world entered	2.29	1.47	4.38	1.67
B & C Third world entered	2.06	1.13	4.24	1.81

Mean task performance was 3.82 for first world entered, 4.38 for second world entered, and 4.24 for third world entered. There may be a slight drop off in task performance and understanding for the third world due to tiredness or boredom, but it did not produce a significant effect, especially when comparing the difference between first and second world entered.

10.2.7 Imaginative Versus Archaeological Worlds

The imaginative worlds were types of game-style worlds. The Ballcourt and the Cave world required complex hand-eye coordination to move and orient the avatar and pick up objects. The Village and the Mountain worlds were really observation-based, the avatar had to find and get close to other objects in the world, rather than aim certain objects (as in the Ballcourt) or orient the avatar in three-dimensional space (such as when using the swimming avatar to dive and pick up objects and navigate a small and twisting underwater cavern).

Results

It is thus possible to categorise Village and Mountain as observation-based games, and score their collective task performance out of 6, then compare the task performance to that of the average archaeological world task performance for group B and for group C. This may indicate how types of interaction more or less 'game-style' can affect task performance (Table 31).

Table 31: Archaeological vs. Imaginative Worlds Task Performance

Types of Worlds/Environments	Task performance			
	B (n=24)		C (n=10)	
	mean	std	mean	std
Hand eye coordination games (Ballcourt and Cave)	2.81	2.50	3.45	2.02
Observation based games (Village and Mountain)	2.75	1.94	3.90	1.20
Archaeological Worlds	4.15	1.03	4.07	1.15

It is interesting that Group C does particularly better in the game-type worlds, but slightly less than Group B in the archaeological worlds. Unfortunately, due to the small size of group C, the fact that one cannot determine how closely group B and group C are similar in terms of demographics, and the conflating issue of the near perfect task performance in the Inscriptions environment across both groups, it is difficult to judge the task performance across these three types of worlds.

10.3 Cultural Understanding

This measure was recorded from a post-experience questionnaire of eighteen questions. It is based on the participants' ability to select the right answer, displaying their recall ability, and ability to extrapolate likely Mayan beliefs and facts (please refer the Appendices for the full list of questions). Results were discrete data with a value of 0 to 18. The data was labelled cultural understanding (understanding in the tables), and was discussed in the previous section. As noted in that section, Group A extrapolated knowledge was not recorded, due to incomplete results, hardware difficulties, and the participants (students) not completing each virtual environment and interaction mode.

10.3.1 Age Group in relation to Understanding

Where demographic data (Table 32) is recorded and considered the independent variable, we found a close to significant correlation between age and cultural understanding (Pearson correlation $r=0.367$, $p=0.072$) and between PC game experience and understanding (Pearson correlation $r=0.337$, $p=0.107$).

Results

Table 32: Group B Age Group and Understanding

Group B (n=24) Understanding	Pearson Correlation	Significance (2-tailed)	std
PC Game Experience	0.337	0.107	0.46
Age	0.367	0.078	0.34

10.3.2 Effects of World Order on Understanding

Section 10.2 showed that differences in understanding between Groups B and C were not considerable. Using ANOVA General Linear Model Type III Sum of Squares with understanding as the dependent variable (Table 33), there is (of course) a significant effect by person (where the person is considered a random effect), but also by which world is being visited. That is to say, the type of world one enters does significantly affect the cultural understanding as scored by the questionnaire. The order is here nearly significant.

Table 33: Group A and B Order Effect on Understanding

Groups B and C (n=34)	Type III Sum of Squares	Degrees of Freedom	Mean Square	F	Significance
Intercept Hypothesis	338.423	1	338.423		.000
Error	66.353	32	2.074 ^a	163.211	
Person Hypothesis	66.353	32	2.074	1.802	.024
Error	71.340	62	1.151 ^b		
Order Hypothesis	5.932	2	2.996	2.578	.084
Error	71.340	62	1.151 ^b		
World Hypothesis	18.699	4	4.675	4.063	.005
Error	71.340	62	1.151 ^b		

a. MS(person)

b. MS(Error)

10.4 Presence Criteria Ranking

This measure recorded participants' ranking of the seven worlds, according to various Presence criteria (see Appendix for criteria). Participants recorded their subjective judgment of the worlds as ranked data, (treated as interval data), with a value of 1 (closest to criteria) to 7 (furthest from criteria). Table 34 shows the questions asked of the participants, who were asked to rank the worlds in descending order (i.e. write 1, 2 or 3 in columns to the right).

When collating these rankings, the author reversed the ranking scores so that value 7 became most challenging, most interactive, etc, while 1 became the least challenging, least interactive etc.

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Table 34: Presence Criteria Questions

No.	Feature: (In) which virtual environment...	Env1	Env2	Env3
1	Did you find the most challenging to either explore, find or manipulate things?			
2	Was the most interesting to you?			
3	Seemed most interactive to you?			
4	Did you feel most closely represented the way Mayans saw their own world?			
5	Most effectively seemed inhabited by real people?			
6	Most felt like you were in the presence of Mayan culture?			

10.4.1 Group A Presence Rankings

Of the 47 participants of Group A who returned survey forms, only sixteen completed all the presence rankings for the archaeological worlds. Hence the Group A presence rankings are noted but not statistically recorded or evaluated, due to incomplete results, hardware difficulties, and students not completing each virtual environment and interaction mode.

Group A saw the Observation-Palace world as the most challenging, most interesting, and most interactive world, even though it should have been the least demanding interaction mode (Table 35). It was deemed closest to the Mayan perspective. The Instruction-Cross world with its chat agents was deemed closest to the Mayan perspective, and most inhabited (not surprising, considering it had chatbots). The Observation-Palace world was considered to most provide the feeling of being in the presence of Mayan culture.

Table 35: Group A Presence Rankings for Archaeological Worlds

Presence (n=16)	Action-Inscriptions		Observation-Palace		Instruction-Cross	
	mean	std	mean	std	mean	std
Most Challenging	2.19	0.83	2.31	0.60	1.50	0.82
Most Interesting	2.19	0.83	2.31	0.60	1.50	0.82
Most Interactive	1.81	0.83	2.25	0.68	1.94	0.93
Closest to Mayan perspective	1.69	0.79	2.25	0.77	2.06	0.85
Most effectively seemed inhabited by real people	1.63	0.72	2.06	0.85	2.31	0.79
Most felt like you were in the presence of Mayan culture	1.56	0.73	2.44	0.73	2.00	0.82

The collated data reveals several surprising items. Firstly, the Instruction-Cross Precinct world was the least challenging (i.e., it received the lowest aggregate ranking of the three archaeological worlds by the sixteen participants of Group A). Even though this world featured three agents, one in each of the Cross Precinct temples, something about the specific environment meant that it was easy to complete the tasks.

Results

Secondly, the participants considered the Action-Inscriptions world to be the least interactive, even though it featured more scripting than the Observation-Palace world, and even though it allowed the user to interact with the environment more than the Instruction-Cross world.

10.4.2 Group B Presence Rankings

When responding to the Presence questions, the ranking by the twenty-four participants of Group B indicated Observation-Palace was the most challenging world even though Action-Inscriptions involved difficult spatial navigation and object manipulation (Table 36). They did list Action-Inscriptions as most interactive (which is as one would expect), but in general they viewed Observation-Palace (the least interactive world), as closest to a Mayan perspective of the three archaeological worlds.

Table 36: Group B Presence Rankings for Archaeological Worlds

Presence (n=24)	Action-Inscriptions		Observation-Palace		Instruction-Cross	
	mean	std	mean	std	mean	std
Most Challenging	2.04	0.81	2.25	0.85	1.71	0.75
Most Interesting	2.00	0.86	2.13	0.78	1.88	0.85
Most Interactive	2.33	0.81	1.58	0.65	2.08	0.85
Closest to Mayan perspective	1.96	0.75	2.04	0.81	2.00	0.93
Most effectively seemed inhabited by real people	1.71	0.69	1.83	0.76	2.46	0.83
Most felt like you were in the presence of Mayan culture	1.92	0.83	2.17	0.70	1.92	0.93

The four imaginative environments (the Cave, the Ballcourt, the Mountain, and the Mayan Village) were also ranked against the three archaeological worlds. Group B cultural presence survey results (n=24), indicate that of all the virtual worlds (both archaeological and imaginative) the participants generally ranked the archaeological worlds higher against the presence criteria than the imaginative ones (Table 37).

Table 37: Group B Presence Rankings for All Virtual Worlds

Group B (n=24)	most challenging		most interesting		most interactive		most Mayan		most inhabited		most cult presence	
	mean	std	mean	std	mean	std	mean	std	mean	std	mean	std
Village	3.13	2.09	2.83	2.20	3.00	2.19	2.92	2.04	4.50	2.38	3.00	1.64
Ball	3.92	2.15	3.79	2.08	4.50	2.34	3.17	2.08	3.67	1.69	3.88	1.85
Cave	4.75	1.92	4.42	2.04	4.21	1.77	3.25	1.96	2.21	1.61	3.13	1.98
Mountain	3.83	1.95	3.50	1.53	2.83	1.76	4.29	1.73	3.58	1.89	3.88	2.25
Action-Inscription	4.25	1.78	4.67	1.79	4.79	1.69	4.54	1.77	4.13	1.23	4.38	1.84
Observ.-Palace	4.42	1.93	4.46	1.91	3.88	1.60	4.88	1.73	4.67	1.71	4.96	1.99
Instruction-Cross	3.71	2.03	4.33	1.99	4.79	1.79	4.96	1.76	5.25	2.03	4.79	1.77

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For only two of the Presence Factors were any of the archaeological worlds not ranked in the top three, most challenging, and most interactive. Interestingly, the Cave was ranked the most challenging, perhaps because it had the most involved navigation and manipulation controls.

For interactivity, the Palace-Observation world was outranked by the Ballcourt and then the Mayan cave (or cenote, as it is known in Mexico). The Instruction-Cross world was far too easy (it was ranked second to last for most challenging), nearly everyone completed all the tasks there, but not for the Inscriptions or for the Palace.

10.4.3 Group C Presence Rankings

Group C task performance results indicated that the Instruction-Palace world is challenging, and this seems corroborated by the Presence questionnaire results. When responding to the below Presence questions (Table 38), the ten participants listed Instruction-Palace as the most challenging world.

Table 38: Group C Presence Rankings for Archaeological Worlds

Presence (n=10)	Observation-Inscriptions		Observation-Palace		Instruction-Cross	
	mean	std	mean	std	mean	std
Most Challenging	2.10	0.74	2.30	0.82	1.60	0.84
Most Interesting	1.80	0.79	1.90	0.74	2.30	0.95
Most Interactive	2.20	0.79	1.90	0.74	1.90	0.99
Closest to Mayan perspective	1.90	0.88	2.20	0.63	1.90	0.99
Most effectively seemed inhabited by real people	2.00	0.82	2.40	0.70	1.60	0.84
Most felt like you were in the presence of Mayan culture	1.60	0.84	2.40	0.52	2.00	0.94

With no Action interaction mode for group C, the ten participants listed Instruction-Palace as most challenging and Observation-Cross as most interesting (neither of which was predicted). They viewed Instruction-Palace as closest to a Mayan perspective.

Unexpectedly, the most interesting world (Observation-Cross) and the most interactive world (Observation-Inscriptions) were considered least interactive and least interesting, respectively. The results tentatively suggest that greater interactivity does not necessarily lead to greater interest, that it can actually be an unwanted distraction.

Next is a comparison of all seven, the three archaeological and the four imaginative worlds, for the ten participants of Group C. For only three criteria (most challenging, most interesting and most interactive) were all of the archaeological worlds not ranked in the top three (Table 39).

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Table 39: Group C Presence Rankings for All Virtual Worlds

Group C n=10	most challenging		most interesting		most interactive		most Mayan		most inhabited		most cult presence	
	mean	std	mean	std	mean	std	mean	std	mean	std	mean	std
Village	3.00	1.89	1.90	1.10	2.70	2.21	2.90	2.02	3.20	2.04	2.60	1.65
Ball	3.50	1.78	4.60	2.12	5.70	1.57	3.70	1.64	3.60	1.90	4.00	1.76
Cave	4.80	2.30	4.00	1.89	3.40	2.12	3.10	1.52	2.50	0.85	3.10	1.91
Mountain	4.20	1.99	3.50	2.32	3.20	1.75	3.30	2.54	3.50	2.42	3.10	2.08
Observ.- Inscription	4.30	1.89	4.10	1.37	4.50	1.18	4.80	1.48	5.30	1.34	4.60	1.43
Instruction -Palace	4.60	1.96	4.60	1.71	4.30	1.95	5.30	1.49	5.60	1.51	5.70	1.64
Observ.- Cross	3.60	2.22	5.30	1.95	4.20	2.10	4.90	2.18	4.30	2.06	4.90	2.02

The Cave was considered the most challenging, and the Mountain was considered more challenging than Observation-Cross. Not surprisingly, of the archaeological worlds, the Temple of Inscriptions scored the highest for interactivity, as it was the only environment that had an action mode of interactivity.

10.4.4 Group B and C Presence Rankings

As the reader may recall, a world is the environment plus the interaction mode. Hence if we consider the three worlds in Group B (shaded grey in Table 40) and the three worlds in group C, we have six worlds. World 1 is Action-Inscriptions, World 2 is Observation-Palace, and World 3 is Instruction-Cross. They were experienced by the twenty four participants of Group B (n=24).

Table 40: Groups B and C Presence Factors Vs. Archaeological Worlds

Averaged Presence Factor per World	World 1 (n=24) Act. Inscript	World 2 (n=24) Obs. Palace	World 3 (n=24) Inst. Cross	World 4 (n=10) Obs. Inscript	World 5 (n=10) Inst. Palace	World 6 (n=10) Obs. Cross
Most challenging	2.04	2.25	1.67	2.10	2.30	1.60
Most interesting	2.00	2.13	1.83	1.80	1.90	2.30
Most interactive	2.33	1.58	2.00	2.20	1.90	1.90
Most Mayan	1.96	2.04	1.92	1.90	2.20	1.90
Most inhabited	1.71	1.83	2.38	2.00	2.40	1.60
Most cultural presence	2.04	2.25	1.96	1.60	2.40	2.00

World 4 refers to Observation-Inscriptions, World 5 is Instruction-Palace, World 6 is Observation-Cross Precinct. These were the three worlds experienced by the ten participants of Group C (n=10). The table shows that most challenging is not necessarily most interesting or even most interactive, and that inhabitation is not necessarily the same as 'Closest to Mayan perspective' or 'Most felt like you were in the presence of Mayan culture'.

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Table 41: Groups B and C Archaeological Presence Factors Side by Side

Group	Action- Inscription B (n=24)	Observation -Inscription C (n=10)	Observation- Palace B (n=24)	Instruction -Palace C (n=10)	Instruction- Cross B (n=24)	Observation- Cross C (n=10)
most challenging	2.04	2.10	2.25	2.30	1.71	1.60
most interesting	2.00	1.80	2.13	1.90	1.88	2.30
most interactive	2.33	2.20	1.58	1.90	2.08	1.90
most Mayan	1.96	1.90	2.04	2.20	2.00	1.90
most inhabited	1.71	2.00	1.83	2.40	2.46	1.60
most cult pres	1.92	1.60	2.17	2.40	1.92	2.00

Comparing the environments in the six worlds side by side, with Group B worlds still shaded grey (Table 41), there appears to have been a big increase in the feeling of being inhabited when switching from Observation mode to Instruction mode (which featured chatbots). Yet Group C rated the Cross Precinct far more interesting when it did not have chatbots than Group B (i.e., was Observation interaction mode only) than when it had the chatbots (i.e. was Instruction mode).

10.4.5 Groups B and C Presence Rankings per Game World

Groups B and C experienced the same game-style interactive worlds. If we collate the presence rankings per hand-eye coordination style worlds (Ballcourt and Cave) and per observation worlds (Village and Mountain), and tabulate them against an average presence ranking of the three archaeological worlds we get the following results (Table 42).

Table 42: Group B Game-World Presence Rankings

Presence Criteria	Group B (n=24)					
	Hand-eye		Observation		Archaeological	
	mean	std	mean	std	mean	std
Challenging	4.34	2.04	3.48	2.02	4.13	1.91
Interesting	4.11	2.06	3.17	1.87	4.49	1.90
Interactive	4.36	2.06	2.92	1.98	4.49	1.69
Mayan	3.21	2.02	3.61	1.89	4.79	1.75
Inhabited	2.94	1.65	4.04	2.14	4.68	1.66
Cultural presence	3.51	1.92	3.44	1.95	4.71	1.87

Despite different interaction modes between group B and group C (Table 43) for the Archaeological worlds, their presence rankings are very similar.

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Table 43: Group C Game-World Presence Rankings

Presence Criteria	Group C (n=10)					
	Hand-eye		Observation		Archaeological	
	mean	std	mean	std	mean	std
Challenging	4.15	2.04	3.60	1.94	4.17	2.02
Interesting	4.30	2.01	2.70	1.71	4.67	1.68
Interactive	4.55	1.85	2.95	1.98	4.33	1.74
Mayan	3.40	1.58	3.10	2.28	5.00	1.72
Inhabited	3.05	1.38	3.35	2.23	5.07	1.64
Cultural presence	3.55	1.84	2.85	1.87	5.07	1.70

However, the small number of Group C participants and the similarity of the other rankings between the two groups suggest that further statistical analysis is not required until a larger sample size is found. However, the overall similarity in rankings between the two groups (Figure 18) is promising.

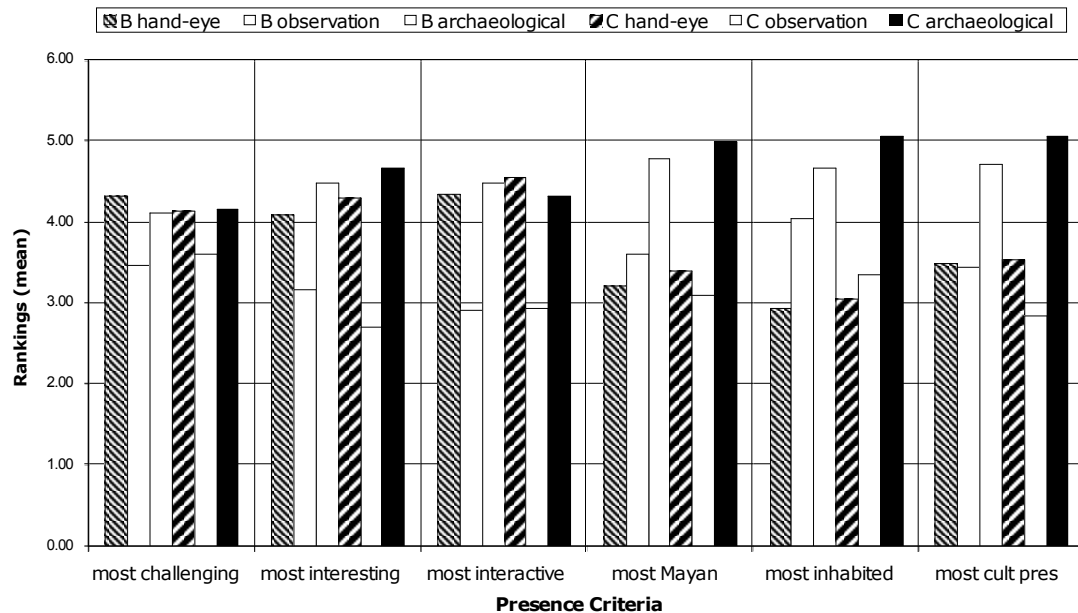


Figure 18: Presence Rankings for Game-style Worlds

Also, the hand-eye games are considered much more interactive in both groups than the observation ones. This is interesting, there was not much more actual scripted interaction in the hand-eye environments but there was more interaction the participant could immediately control. It is possible that interactive agency rather than the amount of overall actual scripted interactivity in the virtual environment is of strong importance to the user.

10.4.6 Groups B and C Correlation of Questions

For Groups B and C, we could calculate how close answers are between the different Presence questions (Table 44). Using statistical correlations, the question

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of whether one felt one was in the presence of Mayan culture, and how closely the virtual world represented the way Mayans saw their own world were significantly similar to each other. Moderately well correlated and nearly significant were the paired questions in rows 2 and 3.

Table 44: Similarity in Paired Presence responses

No.	Presence Criteria (n=34)	Paired Presence Criteria	Correlation	Significance
1	Which felt most like you were in the presence of Mayan culture?	Which did you feel most closely represented the way Mayans saw their own world?	.860(*)	0.028
2	Which did you feel most closely represented the way Mayans saw their own world?	Which most effectively seemed inhabited by real people?	.618	0.191
3	Which did you find the most challenging to explore, find or change things?	Which did you feel most closely represented the way Mayans saw their own world?	.613	0.196

* Correlation is significant at the 0.05 level.

Using the same approach (combining Groups B and C, so n=34), to see which pairs of answers to the below questions had a significantly negative correlation, we find two pairs of near significance and slight significance (Table 45). The more inhabited worlds seemed less interesting, and more interaction seemed to curtail the sensation of being in the presence of Mayan culture.

Table 45: Dissimilarity in Paired Presence responses

No.	Presence Criteria (n=34)	Dissimilar Presence Criteria	Correlation	Significance
1	Which was the most interesting to you?	Which most effectively seemed inhabited by real people?	-.743	0.091
2	Which seemed most interactive to you?	Which felt most like you were in the presence of Mayan culture?	-.644	0.167

10.5 Environmental Recall

People also answered questions that tested their recall of details not directly asked before in the experiment (Table 46). This measure recorded answers as true or false to questions that asked participants to recall features of the worlds in general. Results were interval data, with a value of 0 to 4.

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Table 46: Environment Recall Answers for Groups A B & C

Questions	Group A Answers		Group B Answers		Group C Answers		Total
	% correct	N=variable	% correct	n=24	% correct	n=10	n=
In the environments, did you notice dynamic shadows?	35.71%	42	54.17%	24	39.47%	10	76
In the environments, did you notice other people?	46.15%	39	45.83%	24	49.32%	10	73
How tall were Mayans compared to modern western people?	33.33%	36	45.83%	24	37.14%	10	70
How many real or computer scripted people were in the site?	29.55%	44	79.17%	24	52.56%	10	78

As expected, group B was the most accurate in general, although group C, many of whom were gamers, did surprisingly well in remembering the number of people and working out that the characters they spoke to were scripted bots (chat agents). Surprisingly, less than half overall noticed the dynamic lighting (their avatars cast shadows in real-time). More evaluation might determine whether they subconsciously noticed this or not, and such findings may be of great significance to designers as not having real-time shadows dramatically improves frame rate.

Please note that Group A did not always complete the questionnaire, hence the differences in numbers. Group A results were not statistically evaluated as different numbers of participants answered the questions making statistical evaluation difficult.

Group B and C used the same avatars. Combining Groups B and C and using correlations, other statistically significant relationships were found (Table 47). For both groups together (where $n=34$), there was a significant relationship between the participants' cultural understanding scores and their ability to discern the difference in height between Mayans and western visitors ($r=0.401$, $p=0.0019$, 2-tailed). Both groups saw the same types and sized avatars and both groups could change between the default Western backpacker avatars and considerably smaller sized Mayan avatars.

Table 47: Groups B & C Understanding and Discerning Avatar Stature

Groups B and C (n=34)	Statistical Component	Understanding
Noticing Correct Mayan Height	Pearson Correlation	.401(*)
	Sig. (2-tailed)	.019

There was no significant relationship between cultural understanding and any of the other environment detail recall features.

10.6 Subjective Experience of Time Passing

Participants were also asked to rank the three archaeological worlds they visited, from 1 to 3, in terms of the environment with the perceived fastest perceived frame-rate. Results were taken as interval data, with a value of 1 to 3 (Table 48). Group A results were not recorded, due to incomplete results, hardware difficulties, and students not completing each virtual environment and interaction mode. Groups B and C shared worlds, and they viewed these worlds on the same machines.

Table 48: Correct Observation of Frame-Rate

Environment	Group B		Group C	
	Actual Time-FPS	% correct	Actual Time-FPS	% correct
Inscriptions	6.69	50%	8.62	20%
The Palace	4.21	54%	3.48	40%
Cross Precinct	4.27	29%	6.62	20%

The change in frame speed is due to the changed interaction method. The Palace was the largest environment, but the instruction mode, since it featured three scripted avatars, was the slowest interactive mode. Thus, the Palace is much slower in Group C than Group B, but the Cross Precinct is much faster (since in Group C it does not have the scripted agents). The objective of this measure was to see if there was a statistical link between accuracy in determining frame rate and level of engagement (how interesting the participants found the related world).

Both groups perceived the Inscriptions environment to have the greatest frame rate (Table 49). There was virtually no difference in actual frame-rate between the Palace and the Cross Precinct for Group B, and a large difference between them for Group C.

Table 49: Correct and Perceived Observation of Frame-Rate

Environment	Group B		Group C	
	% correct	Perceived fastest	% correct	Perceived fastest
Inscriptions	50%	50%	20%	20%
The Palace	54%	21%	40%	40%
Cross Precinct	29%	29%	20%	40%

The question of which world had the greatest frame rate was answered most correctly by Group B, although the greatest range in frame-rate was in the group C world and hence should have been easier to distinguish between. More importantly, as predicted, Group B was most adept overall at correctly guessing the ranking of all three worlds. Unfortunately, the rankings do not clearly relate to how interactive and interesting the participants found the worlds, so I cannot say there is evidence

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to suggest the more engaged a person is in a particular world, the more likely they are to rate it higher for frame rate speed. It is puzzling why Group C did markedly less well than Group B when there was a greater variety of frame-rate speed between their three worlds.

There was a significant relationship between game experience and ability to discern relative frame-rate speeds ($r=0.005$, $p=0.005$, 2-tailed).

Group B (n=24) Frame Rate	Pearson Correlation	Significance (2-tailed)	std
PC Game Experience	.554	0.005	0.46

All three groups were also asked in which environment time seemed to go past quickest, the question may have been badly phrased, as it received highly variable answers, and is discounted here.

10.7 Preferred Reasons for Virtual Environments

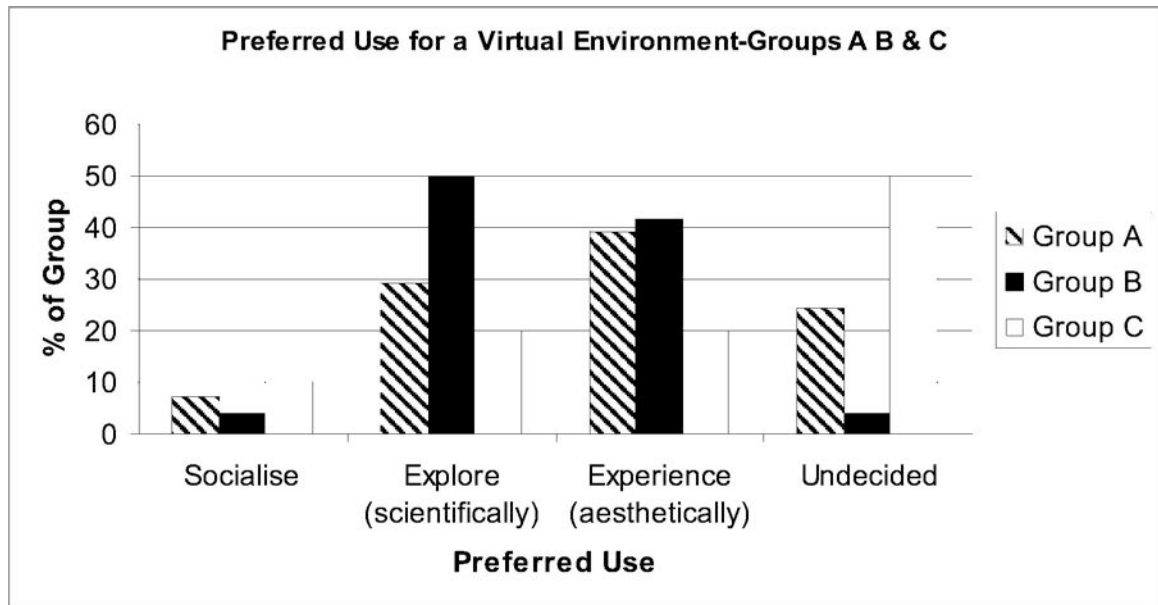
Participants were also asked which type of virtual environment scenario they would prefer (Table 50). Drawing a chart (Figure 19) may make the comparisons clearer. Exploration and aesthetically experiencing the virtual environments were the most popular, especially for groups A and B. Group B was more inclined to opt for scientific exploration rather than aesthetic experience. The Y-axis signifies percentage.

Table 50: Preferred Use of a Virtual Environment

Preferred Type of VE	Group A		Group B		Group C		All	
	No.	%	No.	%	No.	%	No.	%
To socialize with friends.	3	7%	1	4%	1	10%	5	7%
To explore on your own as a scientific and accurate reconstruction.	12	29%	12	50%	2	20%	26	35%
To experience the aesthetic experience of that particular place through digital media.	16	39%	10	42%	2	20%	28	37%
Am not decided either way.	10	24%	1	4%	5	50%	16	21%
Total	n=41	100%	n=24	100%	n=10	100%	n=75	100%

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Figure 19: Chart of Preferred Use



Group C (consisting of ten people from Lonely Planet) had the most puzzling results. Five of the ten participants were undecided on the above questions of preferred type of virtual environment. In an attempt to understand why, I asked all of the ten people in Group C which environment they preferred if the environment was a re-creation of a place that they had never visited before. In answering, they had to choose between exploring this virtual travel environment at their own pace, playing the environment as a game, being guided by an artificial agent (a bot), or socialising with other people in the virtual environment.

Table 51: Preferred Use for Group C Rephrased

Group C (n=10)	Explore	Game	Guide	Socialise	Original answer
To socialize with friends.	1				1
To explore on your own as a scientific and accurate reconstruction.	2				2
To experience the aesthetic experience of that particular place through digital media.		2			2
Am not decided either way.	1	2	1	1	5
Total	4	4	1	1	10

The above table (Table 51) indicates their answers to this rephrased question in relation to the above original question. The original questions populate the first column, and the results from the new questions are in the rows to the right. The "Total" row (in grey) indicates the original breakdown of the answers to the original questions. Four people preferred exploring the environment on their own, four preferred playing a game, one wanted a guide (a scripted computer agent), and

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one wanted to socialise with others.

Six of the ten had played computer games, and six of the ten but not the same six had CAD and GIS experience. Interestingly, two of the four who preferred to visit an environment as a game space, had written in the demographic question that they did not play computer games. This spread of results indicates to me that the rephrasing of the question may have produced better results than the original one asked of all three groups. As only the ten people of Group C were asked this additional questionnaire, it was not statistically evaluated.

10.8 Summary of Results

10.8.1 Quantitative Results

In the design experiment, relating task performance to cultural understanding, the questionnaire recorded cultural understanding through testing what participants remembered, as well as what they were able to recall and extrapolate from web pages that popped up when well-hidden artefacts were clicked. Unfortunately, cultural understanding did not appear to relate closely to task performance for either group B or group C. The Cross Precinct environment was almost perfectly scored for task performance, yet in terms of understanding, it was second overall for Group B and just in front of Inscriptions for Group C understanding (Table 52).

Table 52: Groups B and C Performance and Understanding

Group B (n=24)	Task performance mean	std	Understanding mean	std
Action-Inscriptions	3.88	1.45	1.42	1.14
Observation- Palace	2.67	1.24	2.67	1.09
Instruction-Cross	5.92	0.20	2.21	1.35
Group C (n=10)	Task performance mean	std	Understanding mean	std
Observation-Inscriptions	3.50	1.96	1.70	1.16
Instruction-Palace	2.70	1.49	1.60	1.35
Observation-Cross	6.00	0.00	2.00	1.33

Participants in groups B and C solved the least number of tasks in the Palace environment, but answered more questions correctly there. They solved all the tasks in the Cross environment, but it ranked second on correctly answered questions. The Inscriptions environment ranked second for task performance and last for correct number of answers. While task performance decreased with age (Table 27), the rate of correct answers (cultural understanding) increased with age (Table 32).

There are two possible reasons for this, the questions in the Inscriptions environment were harder than in the other two, or the environments themselves

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confounded the results. Having checked the questions with an archaeology teacher, I believe the problem was with the different types of environment, and the presence survey appears to substantiate this.

There were some statistically significant results for both Groups B and C. For Group B, there was a nearly significant relation of age to understanding, and a nearly significant negative relation of travel experience to task performance. There was a significant relationship between game experience and age, and between game experience and an ability to discern correct frame rate.

When combining groups B and C we gain a total of thirty-four people, and six worlds (that is, six interaction mode-environment combinations). This group had a nearly statistically significant relation between the world itself and the order in which the world was experienced. The results also show a nearly significant effect of world (interaction mode with environment) on task performance, a nearly significant order effect on understanding and a statistically significant relation between world and understanding.

Staggering the sequence of worlds visited by the participants proved to be important. There was a clearly lower average task performance and understanding score for the first world experienced compared to the next two. For B and C treated as a combined group, there was also a relationship between gender, task performance, and cultural understanding, but there were not enough females to make a strong conclusion based on the data.

Secondly, the presence style questions, which asked people to rank the worlds against each other, produced some interesting and surprising results. The imaginative worlds were in general ranked lower than the archaeological worlds. The exception for Group A was the Village, which was ranked first (for most inhabited), and ranked third highest for most challenging.

Group B ranked the Cave as most challenging, and the Ballcourt at third for most interactive. Group C ranked Cave as most challenging, they tied Ballcourt with Instruction-Palace as second most interesting, and they ranked the Ballcourt as most interactive.

These results corresponded with my observation that the Ballcourt was more engaging for Group C. By contrast, Group B ranked the Ballcourt sixth (second to last) for 'most interesting' world. Group A was not included for this part of the evaluation (as they had less time and slower machines than the other groups).

Reviewing the presence rankings of archaeological worlds for Groups A, B, and C is revealing (Table 53). For all three the Palace environment was most interesting. For

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Group B, the Action-Inscriptions world was the most interesting and most interactive world (for Group A it was Observation-Palace).

Table 53: Groups A B and C Top Ranked Worlds

RANKING (1 to 3= highest to lowest)	Archaeological interaction modes		
	No. 1 world-Group A (n=16)	No. 1 world-Group B (n=24)	No. 1 world-Group C (n=10)
Most Challenging	Observation-Palace	Observation-Palace	Instruction-Palace
Most Interesting	Observation-Palace	Observation-Palace	Observation-Cross
Most Interactive	Observation-Palace	Action-Inscriptions	Observation-Inscriptions
Closest to Mayan perspective	Observation-Palace	Observation-Palace	Instruction-Palace
Most effectively seemed inhabited by real people	Instruction-Cross	Instruction-Cross	Instruction-Palace
Most felt like you were in the presence of Mayan culture	Observation-Palace	Observation-Palace	Instruction-Palace

Overall, the Palace was considered most challenging when it had the least interactive mode for Group B, and that was surprising, and not what had been expected. There appears to be an environmental factor that confounds the results. Here the environmental factor outweighed the interaction mode factor.

Worlds with the Instruction interaction mode were of course seen as the most inhabited. However, here inhabitation does not appear to relate to a sense of being close to Mayan perspective or being in the presence of Mayan culture. My observations and above findings indicate the scripted agents were not interactive enough. Another possible reason could be that interaction might lower a sense of cultural authenticity.

The students of Group A rated the Instruction interaction mode highly for cultural presence, Mayan perspective, and inhabitation (Table 35). Yet none of the participants of Groups B or C chose a world with an Instruction interaction mode as 'most interesting world' (Table 41).

It appears from the tables that the specific environment was more important in creating challenging worlds. Environment rather than interaction appears to be a strong factor in generating the feeling one is in the presence of Mayan culture, is probably a factor in what makes the world more or less interesting, and may be a factor in generating a feeling that it is closest to the Mayan perspective.

In short, despite my belief that the environmental content should not drastically affect the results, the environment seems to be a far stronger factor than does interaction mode, for most of the presence responses. There almost certainly

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needed to be richer, and more distinctive and involved interaction modes.

Thirdly, the results for subjective ranking of worlds via frame rate were inconclusive but interesting. A future experiment might compare perceived frame rate and perceived time taken to a perceived sense of engagement.

Fourthly, environmental recall in relation to demographic data also gave interesting results. Environmental recall was also significant for gauging heights of other avatars, in relation to cultural understanding.

My final point, is that using Pearson's coefficients, we can gain some idea of which questions are closer together and further apart in meaning for the people evaluated, and closer to a test of cultural presence. It may be helpful in future to question the amount of cultural presence in terms of how closely the world matched the user's, the designer's and the original inhabitant's perception of the cultural perspective being presented.

The results also suggested a statistically significant relation between "Which [virtual environment] felt most like you were in the presence of Mayan culture" and "Which [virtual environment] did you feel most closely represented the way Mayans saw their own world?" The results also suggested Instruction interaction mode was not interesting and that less interactive worlds were seen as closer to the Mayans' cultural perspective.

10.8.2 Observations

Initially I had thought that presence questionnaires were unreliable, and to some extent, they were. For while all groups according to the presence factor rankings generally found the archaeological worlds to be more authentic and interesting than the imaginative worlds, I found it much harder to drag them out of the latter.

I do not completely trust the superior rankings of the archaeological worlds to the more entertainment-oriented imaginative worlds. I suspect people were ranking the worlds that way because that is the result they expected was desired by the researcher. Labelling worlds 'imaginative' or 'archaeological' should have been avoided, especially when the tests were given to archaeology students, cultural historians, and archaeologists.

Moreover, the artefacts and themes in the imaginative worlds were also based on archaeological records and anthropological theories of the cultural and mythical beliefs of the Mayans. The Ballcourt was based on a direct reconstruction of the Palenqué Ballcourt from photos (I did not have full measurements for this building). Yet people consistently rated the imaginative worlds lower for both "most interesting world", and for the "cultural presence" questions. Not all imaginative

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worlds were navigationally as challenging as the archaeological worlds, but they were generally smaller and more confined. This may be another reason they failed to rank well against the archaeological worlds.

The students in particular were keen to explore all the capabilities of the avatars rather than the archaeological modelling they were meant to be interested in. Some wished to know what parts of the environment and others they could find and destroy.

My interpretation of the above observation is that if virtual heritage projects attempt to improve engagement (and by extension, usability and usefulness), by adopting conventional game-style interaction and design, the more genre-trapped they may become, persuading the student to see them only as a game, and a destructive one at that. However, the results above indicate that even many practitioners as well as the majority of students are keen to explore the more imaginative versions of virtual heritage sites. The challenge is to make the interaction both educational and replete with the 'hard fun' element of engaging games.

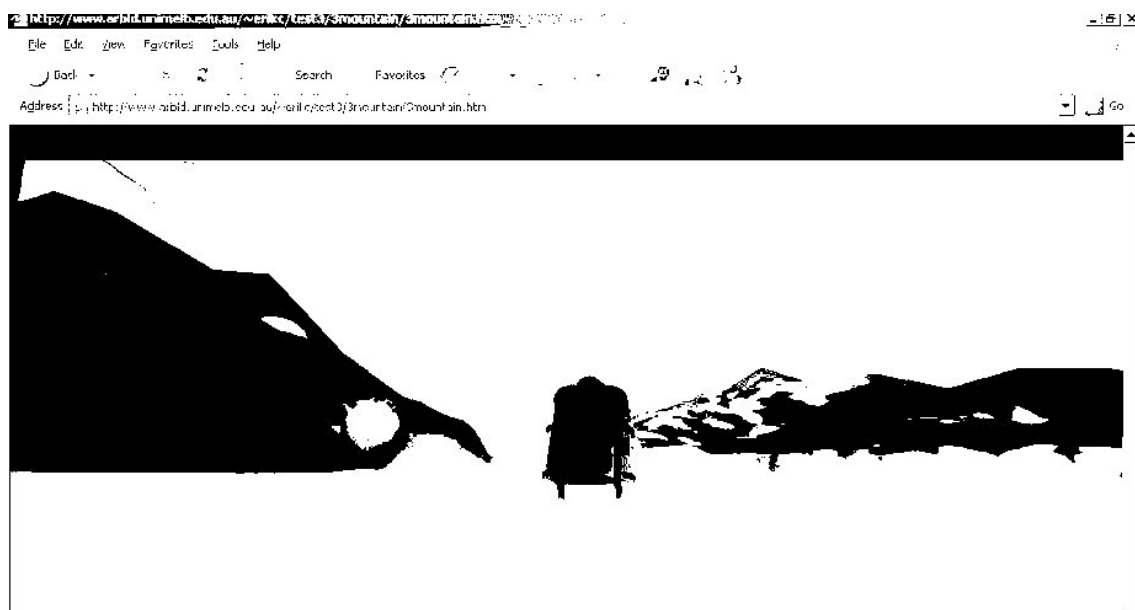


Figure 20: Caiman Outline of Primal Mountain

The ranking of the imaginative and archaeological worlds in terms of game-style interaction (Table 42 and Table 43) indicates that hand-eye coordination games are still more interesting than observation-style games. However, when adding game-style interaction to virtual environments, participants may miss important educational features of the environment as they are concentrating on solving specific tasks. For example, for both Groups B and C, in the Mayan 'Primal Mountain' World, the participants were asked if they noticed the mountain they

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were on was actually a giant caiman (Figure 20). The Mayans believed the world was created from a crack in the back of a turtle or caiman (a type of crocodile). When the heavy fog cleared in this digital reconstruction, the mountain's outline was clearly crocodilian. Not a single person said they had noticed the caiman form, unless it was pointed out to them or they had fallen off the mountain.

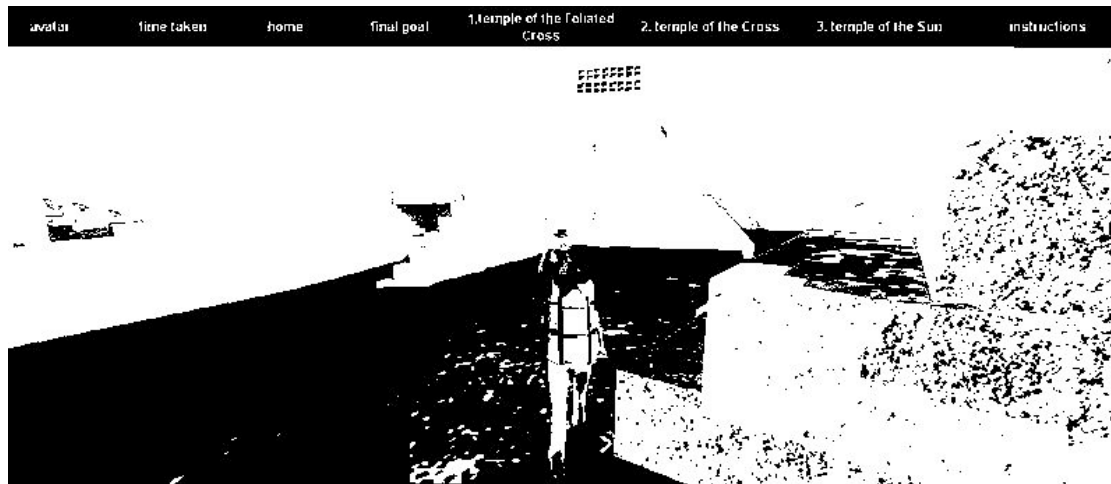


Figure 21: Skybox effect on horizon

Participants from Group B (who had finished the Cross Precinct before their time was up), were also asked to indicate if there was anything wrong with the horizon. Even though they were experienced 3D designers, none had noticed the buildings would fade in or out, as the sky was actually a 'skybox' that followed the user's avatar. In following the user, it would cut out or fade buildings six hundred feet away from the participant. You might be able to see this effect in Figure 21, where on the left of picture the far away tower of the palace is on the edge of the skybox. It appears from the above examples that focused tasks may increase engagement and where following game genres (such as in the Mayan Ballcourt world) can be understood quickly. Setting tasks on the one hand may blind people to technical problems with the background environment, but for the same reason people may not notice background details.

10.8.3 Summary and Design Implications

Firstly, it is now clear that any apparently small variances in environmental content may strongly affect results. Statistical data indicates that environment and interaction mode combine to produce a nearly significant effect on understanding. The findings suggest that engagement relates to how appropriate the interactivity is to the environment rather than what type of interactivity it is. Therefore, the environment that people are experiencing is an important factor.

Teaching history through simulating traditional forms of 'learning by doing' is an

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incredibly understudied research area and of vital importance. Although the interaction modes used in the experimental design were non-violent and non-destructive, the results indicated the least interactive mode (Observation) was the most successful (ranked first and second) for “most interesting” world. These results indicate that talking to scripted agents and navigating through twisty little passages need to be improved on as interaction modes.

Slicing the site was a bad decision, instead a more powerful and stable technology should have been chosen. Having to create three slices of the environment complicated the evaluation. Initially the slices were chosen as they corresponded to the three major distinctive parts of Palenqué, and while this may be true, their content varied to such an extent that applying three interaction modes to the three slices of the site proved problematic.

Only one large part of the site should have been chosen, and quite distinct interactive modes applied to it. The desire to show people archaeological content of the entire site was compelling, but in the end analysis, the point was to build an experimental context, not an educational showcase.

The second largest confounding factor was probably the (unexpected) ease of task completion in the Cross Precinct environment. Tasks for that environment should have been extended or made more difficult to complete.

There was a designer fallacy or bias in attempting to use dynamic lighting as only half the participants noticed it. While dynamic lighting (real-time shadows) may indeed make the virtual world seem more immersive, if it is not obvious to others and decreases frame rate significantly it should have been dropped. Designers may want to convey atmosphere, but in a game-style task-based environment, the end-users want interactive control and low levels of latency (i.e. minimal lag).

Another example of designer bias (thinking end-users want what motivates and challenges the user) was in the designer versus end user perception of ‘most interesting’ and ‘most interactive’ world. The most interactive (i.e., heavily scripted) world was the Cave, but this was not picked up on by many participants in their answers to the related presence question.

Three major related issues appeared that confounded results especially in the Cross Precinct Environment. These related issues not totally planned for were cognitive loading, navigation, and compelling and believable social agents.

The results (particularly the higher engagement but lower task performance in the Palace environments) suggest to me that one can create cognitive overloading in more extensive and less easily ‘mappable’ environments. Evaluating task

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performance via subjective preference ranking of virtual worlds is not useful if the tasks change or if the time spent is of short duration or if the participants have trouble understanding or completing the tasks because they are cognitively overloaded. This is an interesting potential future area of research.

As expected in the design of the experiment, logistics and resource constraints played a part in preventing observation of a clear relationship between cultural understanding and task performance. In addition, as participants were asked to experience seven different virtual environments, they were not given enough time to build up consistent task performance behaviour. The results do not suggest a direct statistically significant link between understanding and task performance.

Navigation must be consistent to obtain results. An academic psychology paper published on this issue (Oman et al, 2003) noted that participants in virtual worlds do not tend to rotate as much as in the real world, and that this may make navigational cues all the more important. Such research seems to substantiate my inference that the Cross Temple Environment was considered not at all challenging because on entry to the world every task can be seen within the screen at the same time (that is, all three temples and tablets). The navigational and orientation features of environments have to be equivalent in affordance to the end user if we are to compare task performance across them.

Creating believable agents was also a problem. While people are attracted to scripted agents (who act as guides), they soon tire of them if they can predict their behaviour. There also appeared to be cognitive overloading when using scripted agents and the agents did not appear to be believable enough. However, they were good navigation landmarks as the participants all saw them very quickly (the scripted agents' default behaviour involved some movement from side to side).

The interface was designed so that people could click on buttons to be reoriented to the next goal or see how far they were from the next goal. This orientation tool was not useful enough. Also, the application meant the world lost 'focus' when the user clicked outside of the world and onto a button on the web page the world was embedded inside. This meant the user had to click back in the world again to 'activate' it, and that annoyed the participants.

For future experiments, a heuristic test or cognitive walkthrough is desirable, but it would also be a good idea to conduct a dummy run by people not used to three-dimensional environments. Experts may overlook navigational issues that would stump someone new to three-dimensional environments.

Performance data is difficult to obtain, perhaps partly because some participants prefer to explore, and some may wish to solve tasks (either with or without time

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constraints). Enough time should be allowed to complete all tasks, and preferably, the participants would only experience a warm up test world, plus at most two worlds to compare.

The audience profile is vital. The statistical results suggest a gaming background does influence the cultural understanding score, and to some extent, task performance. For example, the gender factor had a much greater influence than expected, but a future experiment would need a larger sample size to make any major claims. A more even spread of demographic factors and comparable sample sizes of equal distribution between genders should be attempted in future evaluations.

The evaluation of evaluation methodologies is incomplete and confounded, but it did raise some useful issues and platforms for future research. For example, we could use exit selection to determine which interface is most preferable by a user. Exit selection, means that after a period of time the user is asked to choose their preferred interface or interaction mode for the next stage. The next stage does not actually start, but in thinking it would, the user's selection indicates their subjective preference.

Evaluations should concentrate on assessing task performance against demographic factors, or task performance (of enhanced interaction or a specific design element) against a control group for a single world. Alternatively, the experiment should concentrate on evaluating subjective preference; that is, ranking no more than three worlds against each other, or ranking features inside a single world.

On a more theoretical note, statistical correlations might be used to analyse multiple definitions of presence in order to produce a rough guideline as to the suitable description of a theory. The closer and further apart values may indicate successful (and unsuccessful) synonyms that together may produce a more comprehensive result than a single question for the vague and elastic concept of cultural understanding.

As game legend Warren Spector puts it, "We absolutely must streamline our interfaces and make them so intuitive users forget they're even using an interface. We have to make sure users know exactly what they're supposed to do at all times and challenge them to figure out how." (Aldrich, 2004, p. 175).

11.1 Précis

This thesis has examined a number of apparently disparate fields (archaeology, tourism, virtual environments, 'cyber theory', architecture, environmental psychology, usability studies, philosophy, and presence research).

The link between this interdisciplinary literature review and virtual environmental design is the issue of creating engaging environments through place. How do we learn about culture through place and the elements that constitute place? Can we take these descriptive theories and turn them into prescriptive guidelines for the design of virtual environments?

This thesis attempted to explore this question in four main sections. These have been concerned with

- Fundamental issues (in both theory and practice) for developing meaningful and contextually appropriate interaction.
- Opportunities and challenges in applying game-style interaction to virtual heritage projects.
- Potential evaluation methods.
- Creating a case study in order to test the validity and applicability of these different approaches.

An experimental design assessed task performance, cultural understanding, subjective ranking of the worlds against presence criteria, environmental recall, and personal preference. Correlations between these evaluations were noted, and a suggestion put forward that the type of genre of interaction, its contextual suitability, as well as the demographic background and the cognitive overloading of participants, are important factors that need to be taken into account.

11.2 Theory

In terms of theory, the thesis first considered why critics have not judged commercial virtual environments to be successful. Other writers have mentioned the technological restrictions and lack of suitable content, but not examined in more detail why meaningful virtual environments have not been achieved. Part of this attempt to detail the content-based issues was to see if virtual environment designers could learn contextually relevant and applicable ideas from social scientists and interaction strategies from entertainment media.

Extrapolating from the literature on 'Virtual Reality' it is suggested that problems with currently available virtual environment technology affect a sense of engagement in virtual heritage projects. While virtual environments can simulate historically situated cultural perspectives, the issues of place, presence, realism and education first need to be solved. The thesis then articulated these four thematic issues, proposed new terms and criterion especially in regards to place and cultural presence, outlined new design elements and scenarios, and reviewed evaluation methods for virtual environments (especially those for travel and for heritage studies).

The first major theme that has received widespread academic discussion, without correspondingly involved design application, has been the notion of place. Place may seem a vague and ethereal concept, and those that write about it may be tempted to use esoteric language not immediately accessible to the designers of places (real or digital).

For example, certain writings may introduce the neologisms of continental philosophy to this field but it is not clear how hyperspace or cyberspace distinctions help us improve the design of virtual environments. They may help us understand how 'virtual reality' relates to society in the abstract, but that is arguably not as relevant to designers as the very issues and strategies and reasons for designing the virtual environments in the first place.

Table 54: Types of Virtual Environments

World Type	Required Feature
Visual	Navigation
Activity-supporting	Recall
Hermeneutic	Persistent personalised (identifying) worlds

Instead, this thesis attempted to argue there are three types of generic virtual environments we can usefully discuss, design and evaluate (Table 54). This classification is most usefully based on user needs, and such a schematic may help

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designers build for the types of projected users and the projected needs they most usefully require a virtual environment to fill.

A threefold separation of virtual places may help develop guidelines of more practical benefit to designers, especially when it reflects the end user's needs. A separation of visualisation (for want of a better term), activity-based, or hermeneutic worlds better suits the different audience and designer needs that was outlined in the first chapter.

The last type of virtual environment, the hermeneutic, exists in two different senses. On the one hand, this type of virtual environment might act as a symbolically projected identity, dynamically customised by us as the visitor to reflect our social and individual values and outlook. On the other hand, a virtual environment might be hermeneutic when it affords meaningful interpretations of its shareholders (clients and subjects) to those that visit it.

Chapter 4 argued that this feeling of visiting an inhabited hermeneutic space is missing. The sensation that a virtual environment is inhabited and 'modelled' by a thematic cultural outlook and identifiable social agency is not a feeling I associate with visiting virtual environments. Part of the problem has been that many writers have confused cultural presence with social presence.

While culture is a projection of society, and the mirror by which society can see its own values, we need to separate the two, for social presence does not necessarily lead to cultural presence. If three hundred children rush into cybercafés around the world to meet each other in a virtual heritage environment, they may experience social presence. They may well make new friends, argue, or be bullied by others. Yet that very social engagement with others may destroy their feeling of cultural presence, they may ignore or trivialise the cultural information and setting of the virtual environment. Cultural presence requires an encounter with a unified social agency that attempts to materialise its desires and values by giving these forces material expression. Landscapes, clothing, and even hardware tools, are all material reflections of a society's immediate goals and long-term ideals.

Chapter 5 suggested there are various meanings and interpretation of 'realism', and reasons why photo-realism may not always be required. It is highly probable that in our attempts to advance technology and to preserve historical knowledge through digital means, we have over-emphasised the values of photo-realism at the expense of cultural presence.

In many cases, photo-realism is a worthwhile goal. However, for depicting intangible heritage, and for participatory academic debate, it may not be the most

useful means of depicting cultural knowledge. It may be difficult to reconcile interactivity with photo-realism, and the latter may imply an authoritative knowledge of the culture that the world designers do not in fact possess. Attempts at static realism may also prevent us from seeing the local cultural perspective, or perhaps even be fully aware of the archaeological and anthropological debates and issues that relate to the site in question.

11.3 Design Elements

The second major part of the thesis (chapters 6-7) attempted to summarise useful features and elements of computer games and other interactive virtual environments that made them more engaging.

Embodiment (via an avatar) may help increase the visceral part of the experience but interaction turns it into a game. Awareness of other cultural perspectives may be far more achievable than understanding of others cultures. For full immersion takes time and concerted understanding. Games trivialise consequences; one takes silly risks and does not care about others unless respect and recognition of their social status is required by the gamer.

We can increase the interaction required and hence potentially increase the engagement of people in virtual archaeology (Anderson, 2003). However, most games are violent and people can become trapped into a game genre, the completion of a task may reduce the actual cultural acquisition. In addition, a set interaction time may reduce cultural learning and engagement (if the task is too challenging).

11.4 Evaluation Methodology

The third major part of the thesis (chapter 8) surveyed evaluation methods that we might usefully apply to virtual heritage environments using the interactive methods and features we have learnt from studying popular computer games.

In evaluating virtual heritage, we have to consider several problematic factors. The variety of audience in required learning style, computer experience and background archaeological or place knowledge may vary wildly. Most technology is platform dependent. It can be difficult to test cultural learning acquisition insitu. We may also need post world experience results but questionnaires often produce misleading statistics (participants may hurry to finish them, guess at multi-choice questions, or attempt to produce 'pleasing' answers).

11.5 Experimental Design and Results

The final major part of the thesis (Chapter 9 and 10), attempted to design, build and evaluate a virtual heritage environment to assess which modes of interactivity most helped understanding.

The case study attempted to evaluate the effect on cultural understanding of three different interaction modes, each teamed with a specific slice of the digitally reconstructed environment. The three interaction modes were derived from a descriptive theory of cultural learning as instruction, observation and action (trial and error).

A secondary aim was to ascertain whether task performance was similar to the development of understanding reached by participation in the virtual environment. A hypothesis was that if task performance is equivalent to understanding and engagement, we might be able to evaluate the success of virtual heritage environments (through engagement and education), without having to annoy the user with post-experience questionnaires.

Reasonably accessible and affordable technology was sought, in this case a beta product, and the evaluation suffered from the chops and changes of beta product testing, such as changes in promised features, and unreliable or missing documentation. New forms of presentation (such as the web-button HTML interface), and new scripts were devised.

Results show the importance of recording demographics (in this case age group and gender), the strong effect of context on the choice of interaction, the strong effect of navigation, and a significant relation between gaming experience, task performance, and understanding. It uncovered a potential new factor for consideration by future researchers, and that is cognitive overloading (including too many interactive processes for the participant to cope with effectively while immersed within a virtual environment).

Game-style interaction may also be intuitive for navigation and task-performance, and reduce cognitive loading, but at the expense of understanding cultural significance. The results do suggest that gaming experience relates to task performance, and that social agency (via scripted agents) need to be very believable in order to evoke a sense of presence. The author's interpretation of the findings suggests that while agents can act as powerful navigation cues, if they are not believable then they are ignored.

It also appears very difficult to gain a sense of cultural learning from multi-choice general knowledge questions. Many people (and students in particular), prefer to

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randomly explore and then just guess answers when in an evaluation situation. This suggests that evaluation should be as much an integrated part of the virtual learning experience as possible. Usability experts such as Norman (2001, para. 29) seem to agree:

Museums and video arcades exploit similar themes: meaningful activities, learning that takes place invisibly, not as the objective, but naturally, effectively. Exploiting social interaction and discussion. Participants don't think of themselves as interacting with technology, they think they are doing something interesting: discussing an interesting topic, playing basketball, riding a jet-ski, skateboarding. They exploit social interaction and cooperation. The result is high intense concentration, true learning, with people anxious to go back and do it again, paying for it out of their own money.

11.6 Lessons Learnt

In short, the experimental design has not produced completely clear and significant results due to resource constraints and perhaps overly ambitious aims. Yet, its educational benefit to the author has been immense. Implementing these design ideas forced immediate encounters with practical constraints and issues. The evaluation, for example, has led to new and much improved ideas for future evaluations, and for more verifiable design guidelines.

As a result, it is now clear that the theoretical explanation of cultural learning developed was descriptive rather than prescriptive. This means the theory is not a good model for evaluating cultural learning; most cultural learning is actually hybrid. Evaluating cultural learning in terms of separable interaction modes is thus not as useful as other forms of evaluation. This thesis suggested some alternative ways of transmitting culture via game design and they will be returned to briefly in section 11.7.

Secondly, the issue of social agency needs to be examined more carefully. When we design a multi-user environment there are several complex etic-emic issues that can increase or decrease the sense of social presence, of cultural presence, and engagement. We should consider carefully the notion of alterity and whether other users need to be familiar or foreign/different, not just real people or scripted agents. We should also be careful of the Instruction mode-where agents are merely used as static guides.

Thirdly, for the users, a warm-up environment is essential. Accounting for the order effect of learning in virtual environments is also important. Evaluation environments should be clearly set for classroom, small group or individual

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participation, including acoustic separation from others where necessary.

Pre-testing with not just experts but also beginners can also help reduce the possibility of designer (expert) bias - the tendency to make complex and difficult but aesthetically pleasing worlds.

Advanced techniques that slow down the environment in order to create effects that are more realistic may not be noticed by participants engaged in solving tasks. In the example of the experimental design, the use of dynamic lighting (dynamic shadows) may appear highly immersive to the world designer, but have little or no effect on the actual participant's sense of immersion. The author was too heavily affected by the designer affliction, adding in features that most members of the public would not notice.

It would be advisable to change some major aspects of the experimental design if there was the opportunity to repeat the exercise. Apart from changing the choice of modelling and rendering software (which was taken off the market on December 19, 2004, after being in beta for three years), one could also try to simplify the evaluation process.

Table 55: Suggested Environment Evaluation Method

Session	Audience	World 1 and World 2	Audience	World 2 and World 1
1	User Group 1	Environment 1+Interaction A	User Group 2	Environment 2+Interaction A
2	User Group 1	Environment 2+Interaction A	User Group 2	Environment 1+Interaction A
Result	Track preference between Environments 1 and 2, and Interaction remains constant.			

In future, it would be more effective to use a factorial design (Table 55) for subjective ranking of worlds. However, one could try using only two environments with one interactivity mode, and then swap the environments around, with the audience evenly separated according to their background (the most important demographic factors).

Table 56: Suggested Control Group Evaluation Method

Session	Audience	World 1 and World 2	Control	Demographics
1	Group 1	Environment 1+Task A	Yes	Spread evenly across Audience Groups 1 and 2
2	Group 2	Environment 1+Task B	No	

Task performance needs to be evaluated over a far longer time, and preferably in more controlled conditions. For example, we could use a control group to compare task performance and demographics (Table 56). If possible, both groups could be evaluated at the same time, or after each other. If evaluated in succession, care would need to be taken by the invigilator that they do not treat each group differently.

Table 57: More Complex Factorial Evaluation Method

Session	Audience	World 1A and World 2A	Audience	World 1B and 2B
1	User Group 1	Environment 1+Interaction A	User Group 2	Environment 1+Interaction B
2	User Group 2	Environment 2+Interaction A	User Group 1	Environment 2+Interaction B
Result	Track preference between Worlds 1A-2A, Environments 1 and 2, and Interaction 1 and 2.			
Note	One would need to split groups 1 and 2 into 4 to avoid ordering effect.			

If we need to evaluate task performance and subjective preference of worlds, we could use a more complex factorial design (Table 57). Here it is assumed both groups would be identical in composition and therefore likely to give equivalent responses.

It is best to restrict the evaluation to four worlds that are tested as the independent factors, that is, two environments with two interaction modes only. Different questions could be asked instead of the 'which type of virtual environment do you prefer' question, and participants would not be asked to rank frame-rate across worlds. They would however be asked to record the perceived time taken to perform each task.

11.7 Summary and Future Directions

Due to the paucity of prescriptive guidelines for the development of virtual environments that focused on cultural learning, this thesis had to define a notion of culture, types of place, cultural learning, and cultural presence. In order to test these definitions and criteria it also had to scope new methods of evaluation contextually appropriate to virtual heritage environments, hence the chapter on methodology (Chapter 8).

The paucity of studies on interaction suitable for historical and heritage reconstructions became evident through this research. A possible solution is to match generic forms of interaction in entertainment design with social interaction in distinctive cultures and historic periods. A second approach is to apply game genres to suitable heritage reconstructions. We could also evaluate the usefulness of applying game genres' social identities on participants and compare the results to a non-socially constrained environment.

One way of assessing cultural information transmitted is to see culture as a survival mechanism. Many '3rd person shooter' computer games such as Doom, Quake, Unreal, and Heretic, gain their popularity through challenging the participant to survive in a hostile world populated by aggressive agents. While such computer games can be highly engaging, and do offer interesting methods of interaction, they typically do so to the detriment of cultural understanding, and certainly to the

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detriment of understanding and empathising with the local inhabitants and their unique cultural perspectives.

The chapter on games also briefly described the notion of individual avatars that can interact with each other while being surrounded by their own virtual worlds and unaware the world of the other avatar is completely different. This scenario would allow for understanding through sharing dialogue or interaction that makes the other's world or your externally perceived identity obvious to you. One might call this an example of hermeneutic transfer. I believe this method offers some rich and interesting research opportunities.

The other approach deserving further exploration is the idea that I briefly mentioned in the chapter on games (sections 6.4.3-6.4.4). Combining the role-playing and the spy game ideas, a promising option is to evaluate a multi-user virtual environment game where the task is to imitate local inhabitants' behavior and dialogue in order to move up the social ladder without being caught (by scripted agents or by other users). There could be a mix of scripted characters and other real-world users, all are trying to detect and catch out inappropriate behavior, interaction or dialogue (inappropriate in terms of space, time, or social encounter).

This scenario hopefully addresses some of the problems of social presence and cultural presence. On the one hand, multi-user environments are inherently engaging; on the other hand, we may wish to restrict users' contextual interaction and dialogue so that they learn about the local culture and not use the setting as a mere chatroom.

By asking users to imitate inhabitants and avoid detection (by agents or other users), we are introducing challenging game elements while at the same time allowing them to learn contextually relevant behaviour and local knowledge. A changing mix of scripted characters and real world users adds a form of mystery and engagement, and helps ensure a reasonable level of challenge persists after the initial learning period.

Excessive playing of computer games may lead to physical inactivity, exacerbate social alienation, or numb players to graphic acts of violence. Notwithstanding these concerns, there is great scope for evaluating game genres and gamers' profiles to understand how people learn by trial and error, whether current generations do process information differently, and whether we can gain a sense of place without ever having visited the actual locale. There are many people who cannot easily travel to either a classroom or a heritage site, or who have difficulty learning in conventional classroom settings, but that does not mean that they do not want to experience other places and other cultures.

Conclusion

The complexities of environmental design, uncertain audience needs, the vagueness of 'cultural learning', and technological constraints of processing and networking, ensures that applying of contextual interaction from entertainment media to accessible virtual heritage environments is a complex process. This thesis attempted to create a prescriptive and verifiable theory of types of place in virtual environments in order to help understand and simplify that process. The starting point was to formulate and then use interaction metaphors and techniques from activity-based virtual environments (computer games), to evaluate cultural understanding, task performance and subjective preference of a virtual heritage site.

The last two of the four major research questions were focused on, namely realism versus imagination, and whether game-style interaction can help or hinder the learning experience. The more archaeological worlds appeared to be preferable to the imaginative ones for cultural understanding. Applying game-style interaction that are very genre-based increased the useability but not the usefulness (for learning about another culture), as users can become 'trapped' inside the genre, only looking for objects that suit a fixed and limited mindset.

Due to the experimental design conditions (too many environments and a lack of time in each one), statistically significant data on task performance was not achieved. This meant "evaluation of user engagement without simultaneously interrupting the user's feeling of engagement" was not verified. However, the experimental design did reveal important design issues; it highlighted the importance of recording demographic factors, the possibility of cognitive overloading, and it indicated how essential it is to match the type of interaction to the content in order to improve the participant's understanding and awareness of other cultures.

Several assumptions in academic literature were challenged by the results. For example, the more 'inhabited' or 'interactive' environments were not considered more interesting or more 'Mayan'. This suggests that cultural presence is not synonymous with social presence and that cultural learning is too hybrid in nature to be broken down into three distinct modes and tested. In addition, a descriptive theory does not necessarily make it suitable as a prescriptive and verifiable theory. The practical outcomes have also highlighted potential future research areas. There is a pressing need to design, modify, and test interactive genres for learning about historical and cultural information through trial and error-based procedural learning that best utilises the unique real-time and collaborative potential of digital media.

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12.4 Terms and Definitions

AGENT: (from Roddy, 2000, para. 7):

"An agent is an autonomous software object that is capable of making decisions and taking actions to satisfy internal goals, based upon its perceived environment." However, the test case in this thesis uses agent in the broader sense of a computer- scripted avatar that reacts according to the proximity of human participants and how often they have approached the agent.

ARTEFACTS: "are phenomena produced, replicated, or otherwise brought wholly or partly to their present form through human means" (Schiffer and Miller, 1999, p. 12).

AVATAR: A graphical representation of a user or a character controlled by a user.

COMMUNITY: A group of people interacting in some fashion over an extended period of time, who during that time share identification with each other, and to some extent actively attempt to share beliefs or knowledge for a common goal or in regards to a shared purpose (such as learning a specific tool or discussing a certain topic).

CO-PRESENCE OR COPRESENCE: Co-presence can only take place with a system where you have the sense of being in another place or environment other than the

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one you are physically in and being there with another person. Culture: Culture expresses shared beliefs and ritualised habits of social agents towards each other and their environment via artefacts and language.

CULTURE: Culture expresses shared beliefs and ritualised habits of social agents towards each other and their environment via artefacts and language.

CULTURAL PRESENCE: The feeling of being in the presence of a similar or distinctly different cultural belief system. Cultural presence may cover a spectrum of understanding with varying intensity. It may be felt, understood, entered unself-consciously, empathized with, or observed but not understood.

CYBERPUNK: A subgenre of Science Fiction made famous by William Gibson's novel *Neuromancer*.

EMIC: An insider's (local's) view of their own culture's inter-relationship of concepts and meanings. In anthropology it is used to describe the relevance and meaning of concepts and categories from within the same cultural perspective.

ENVIRONMENTAL PSYCHOLOGY: a branch of psychology concerned with providing a systematic account of the relationship between a person and the environment.

ETIC: An outsider's (stranger's) view of a culture. More specifically, it is used to describe the anthropologist's method of describing cultures from their own external cultural perspective. Palimpsest: A manuscript inscribed by writings written over each other at various times.

GAME: My definition: a game is a challenge that offers up the possibility of temporary or permanent tactical resolution without harmful outcomes to the real world situation of the participant

GAME-PLAY: Aldrich (2004, p. 240) defines as gameplay as "The combination of cyclical, linear, and open-ended content, and other elements, that makes a computer game addictive."

GAME-STYLE INTERACTION: interaction that uses the interactive elements commonly found in games. These elements include dynamic places, culturally constrained artefacts (including maps), embodied and socially embedded agency, as well as rewarding goals reached by completing contextually appropriate tasks.

HERMENEUTIC: A medium that allows for interpretation of different cultural and social perspectives.

HERMENEUTIC RICHNESS: The degree to which an experienced environment may allow awareness of cultural presence, or awareness of one's own ability to express oneself symbolically to oneself or to others in the virtual environment. In other words, it is the range and intensity of overlaying interpretations afforded to a visitor

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through a virtual environment which either

- (i) Allowed a culture to express itself symbolically through its modification and augmentation of the local environment and artefacts, or
- (ii) Allowed one or more individuals to express or reveal (to others or to themselves) their personal identity, values, and expectations.

IMMERSION: Being completely involved in something, and/or not aware of something else.

INTANGIBLE HERITAGE: The Convention for the Safeguarding of the Intangible Cultural Heritage (UNESCO, 2005, para. 1) defines the intangible cultural heritage as:

The practices, representations, expressions, as well as the knowledge and skills, that communities, groups and, in some cases, individuals recognise as part of their cultural heritage. It is sometimes called living cultural heritage, and is manifested inter alia in the following domains:

- oral traditions and expressions, including language as a vehicle of the intangible cultural heritage;
- performing arts;
- social practices, rituals and festive events;
- knowledge and practices concerning nature and the universe;
- traditional craftsmanship.

The intangible cultural heritage is transmitted from generation to generation, and is constantly recreated by communities and groups, in response to their environment, their interaction with nature, and their historical conditions of existence. It provides people with a sense of identity and continuity, and its safeguarding promotes, sustains, and develops cultural diversity and human creativity."

MUD or MUDs: Multi-user domains.

PLACE: A recognisable tract of space that in some physical or conceptual way evokes a sense of social agency (conscious or habitual intentions of people), a certain type of behaviour, or a personal emotional reaction.

PALIMPSEST: A manuscript inscribed by writings written over each other at various times.

PRESENCE: The subjective sensation that one is present in a three-dimensional environment that is mediated by digital technology. Schuemie et al (2001) note there is also an ecological view of presence. It is as follows

1. Situated affordances, by Gibson (1979), how the environment allows you

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to do certain tasks, and this depends on what sort of animal you are.

2. Perception-action coupling, perception dependent on action.

3. Tools become 'ready-to-hand'. "According to Heidegger, using a tool precludes the user from possessing a stable representation of the tool. The user is no longer aware of the tool itself but only of the usefulness the tool has in whatever task is performed."

PRESENCE CRITERIA: Schubert et al (2000), follow Steuer (1992, p.80), in listing distinguishing Presence criteria of Virtual Reality from other media as Interactivity ("the degree to which users...can influence the form or content of the mediated environment"). Also, vividness ("the ability of a technology to produce a sensorially rich mediated environment"). Content usually means inanimate objects, and/or animated characters/avatars. Interactivity includes an exploration factor, and a predictability and interaction factor. The latter may also be called the anticipation factor (Witmer and Singer, 1998). Together, they create a meshing factor, how one's personal reactions mesh with one's online reactions.

SOCIAL PRESENCE: The degree to which a person experiencing a virtual environment feels part of potential or actual social interaction with at least one other being also capable of social interaction and/or the degree to which they see social interaction (mutually perceived and understood) between two or more intelligent beings. One may argue whether social presence is social presence only when perceived to be so by one or all of the participants, or perceived to be so by external observers, or perceived to be so by all parties.

VIRTUAL: Simulated version of reality; performing the functions of something that is not actually (physically) there.

VIRTUAL REALITY: Schroeder (1996, p. 2) defines it as follows: "Virtual reality, or VR, is often taken to refer to a computer linked to a head-mounted display and a glove. VR systems give the user a sense of being inside a computer-generated environment and of being able to interact with it." For the purpose of this thesis, Virtual Reality is defined as the experience a participant has of a three-dimensional and multimodal simulation or abstraction of a comprehensible situation that has some degree of perceived interactivity.

13.1 Evaluation Questions

13.1.1 Timing of Groups per Site and Per Interaction Method

Each class of 15 participants were divided into three groups (A, B, and C, dependent on the pc they choose) so that results can be staggered.

13.1.2 Time Taken For Participation

6 minutes warm-up environments
A1-C1: Group A-C first 01-12 minutes
Questionnaire 1 [5 minutes]
A2-C2: Group A-C first 12-24 minutes
Questionnaire 2 [5 minutes]
A3-C3: Group A-C first 24-36 minutes
Questionnaire 3 [5-minutes]
Final Questionnaire 5 minutes
Total time for environments: 36 minutes plus 6 minutes for warm-up environment.
Total time for questions: 20 minutes
OVERALL time: 62 minutes.

13.1.3 Information Collected

Information collected consisted of five main types of data.

- The time taken to complete each stage (apart from the warm up).
- Tasks completed, events triggered by proximity of the participant.
- Questions at end of each virtual environment experience.
- Preference results (asked to rank above interaction modes in terms of user enjoyment, educational effect, and by which environment most afforded a sense of cultural presence, and of inhabitation.)
- Demographic (age, gender, pc experience, 3D experience, travel experience) information collected by HTML form online. No name or student ID was asked.

13.1.4 Questions (at end of immersion in each environment):

There were 18 questions, 6 at the end of each environment experienced.

Inscriptions

At end of experiencing the Inscriptions Environment, participants were asked:

The Temple of the Inscriptions, named for the hieroglyphic texts on the inner walls was built to commemorate Lord Pakal. We discovered his name through	
	Comparing glyphs with the existing Mayan language.
	From Spanish documents compiled by priests and conquerors and enslaved Mayans.
	From Mayan books (codices) written in deerskin.
	All of the above
The carvings throughout the Temple of Inscriptions recounts	
	The accession of Mayan Kings and Queens to the throne.
	The accession of Mayan Kings and Queens to the throne, important events, and the creation of the world by the Gods.
	The accession of Mayan Kings to the throne, important events, and the creation of the world by the Gods.
	The accession of Mayan Kings and Queens to the throne, local officials, important events, and the creation of the world by the Gods.
Inside the sarcophagus were found the remains of Pakal. The utensils found	
	Was currency that paid for his entry into the Underworld (Xibalba).
	Were symbols of life and death
	Were symbols of kingship
	Were symbols of life and death and kingship.
The river that runs alongside the Temple of Inscriptions is to	
	The east of the Temple
	The west of the Temple
	The north of the Temple
	The south of the Temple
If you visit a Mayan ball court you can recognise it as	
	The area will be flat and mown
	The area will be flat, and vary greatly in size, and may have skulls buried under it.
	There will be a flat area, with a hoop on each of two adjoining walls
	The ball court may be any of the above, and may have strange acoustic features as well.
We believe the ball court represented	
	The Mayan king as the ancient hero who was decapitated and revived in the ancient ballgame against the Lords of the Underworld.
	The fading and return of Venus as morning and evening star.
	War
	All of the above.

13.1.5 II. Cross Precinct

At end of experiencing the Cross Precinct Environment, participants will be asked:

Tablet of the Temple of the Foliated Cross describes	
	The passing of the kingship from Pakal to Chan-Bahlum his son.
	The life of Chan-Bahlum.
	Mythical characters
	We are not sure.
Tablet of the Temple of the Cross-describes Yax Naab Chak (God I) in cosmic battle with the Death Lord. This represents	
	Only at Palenque, the spirit of Kings
	Throughout the Mayan world, the animal soul of people falling sick and falling to the underworld.
	The cycle of life and death
	B and C.
Tablet of the Temple of the Sun depicts a baby jaguar that in turn represents the King as	
	Jaguars were the rarest animals to be found.
	Jaguars had the most luxurious pelts.
	Jaguars represented the most powerful animal spirits as they could swim, run on the land, or climb trees.
	Jaguars were the most feared animals in Mesoamerica.
The three temples represent	
	The three stones of creation
	The growth and death i.e. the life cycle of Maize
	The rise and fall of the sun
	All of the above
Judging by the siting of the temples and their contents	
	The Temple of the Sun symbolizes death,
	The Temple of the Foliated Cross symbolizes death
	The Temple of the Cross symbolizes death as it faces north.
	The Temple of the Cross symbolizes death as it faces north.
The Temples were designed	
	To be of general access to the public
	To be like giant billboards where everyone could see the sculptures on the roof combs and on the balustrades.
	To be accessed depending on social rank, only high lords and the king were allowed into the inner sanctuaries.
	All of the above except for A.

Appendices

13.1.6 III. The Palace

At end of experiencing the Palace Environment, participants will be asked:

The East court had steps of various heights to	
	Best accommodate various sculptures.
	To unsettle guests.
	Because the Mayans did not spend a great deal of care on stone construction
	We are not sure.
Oval tablet in House E shows Pakal sitting on a throne made of	
	A jaguar.
	A creation stone.
	A double headed jaguar stone.
	Only B and C are correct.
Tower: Which of the following is most accurate?	
	This picture cannot be of an observatory as Mayans did not have telescopes.
	This picture could be of an observatory because during solstice the light falls directly onto the ledge.
	This is a picture of the only Mayan observatory known to us.
	This is not a picture of the observatory – the Mayans only viewed the stars to indicate ancestors just as some of us use the stars for astrology.
The buildings of the Palace	
	Would have the roofs and roof combs covered in red, yellow, and blue sculpture.
	Masks would cover the sides of houses.
	All the buildings would have been covered in pink-red plaster
	A and B only.
Under the Palace near the Tower, the Mayans used the river to	
	Create running water for a toilet
	Wash domestic utensils
	As a symbol of life
	Act as an escape in case of attack
Inside House L and also in two other places are stairs that descend into the substructure. They were built as	
	They provide access
	They are needed to provide access to an artificially created cave, which symbolizes the birth of creation.
	They already existed.
	They were designed to allow dignitaries to escape from invading armies.

13.1.7 Final Questionnaire:

The below is be asked at the end of the experiment.

A. Preference rating

Please rank in descending order (i.e. write 1, 2 or 3 in columns to the right)

No.	Feature: (In) which virtual environment...	Env1	Env2	Env3
1	Did you find the most challenging to either explore, find or manipulate things?			
2	Was the most interesting to you?			
3	Seemed most interactive to you?			
4	Did you feel most closely represented the way Mayans saw their own world?			
5	Most effectively seemed inhabited by real people?			
6	Most felt like you were in the presence of Mayan culture?			

13.1.8 B. Environment Awareness questions

How much time did you spend in each environment? (Write in minutes)		
Env1	Env2	Env3
Rank the environments (from 1 for fastest to 3 for slowest) for how slow they seemed to be for updating the screen		
Env1	Env2	Env3
In the environments did you notice? (Tick one or more)		
<input type="checkbox"/>	Shadow	
<input type="checkbox"/>	No shadow	
<input type="checkbox"/>	Sometimes shadows in the environments?	
In the environments did you notice? (Tick one or more)		
<input type="checkbox"/>	Real people?	
<input type="checkbox"/>	Scripted characters posing as people?	
<input type="checkbox"/>	3D objects that look like people?	
<input type="checkbox"/>	Artificial intelligences that could respond to your question as if they were people?	
<input type="checkbox"/>	None of the above?	
How tall were Mayans compared to modern western people? (Tick one)		
<input type="checkbox"/>	Same height?	
<input type="checkbox"/>	30 cm shorter?	
<input type="checkbox"/>	15 cm shorter?	
<input type="checkbox"/>	Taller?	
How many real or computer scripted people were in the site? (Tick one)		
<input type="checkbox"/>	Just you	
<input type="checkbox"/>	2	
<input type="checkbox"/>	3-5	
<input type="checkbox"/>	Up to 15	

13.2 Publications and Conference Proceedings

1. Champion, E. (2005). Virtual Places, *Encyclopedia of Virtual Communities and Technologies*, George Washington University. To be published.
2. Champion, E. (2005). Cultural Presence, *Encyclopedia of Virtual Communities and Technologies*, George Washington University. To be published.
3. Champion, E, and Dave, B. (2005). Dialing up the Past, (book chapter). In S. Kenderdine and F. Cameron, (Eds.). *Theorizing Digital Cultural Heritage*, MIT Press: Media in Transition series. To be published.
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6. Champion, E. (2004). Indiana Jones and the Joystick of Doom: Understanding the Past via Computer Games, *Traffic, Traffic Number Five "A Vision Splendid"*. 2004, 47-65.
7. Champion, E. (2004). The Limits of Realism in Architectural Visualisation. In H. Edquist & H. Frichot (Eds.). *LIMITS, Proceedings From the 21st annual conference of the Society of Architectural Historians Australia and New Zealand*, 1, (pp. 88-98). Melbourne: SAHANZ.
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11. Champion, E., Dave, B and Bishop, I. (2003). Evaluation of Interaction versus

- Engagement for Virtual Heritage Applications, *CAADFUTURES 2003*, October 2003 Taiwan. Published in *Digital Design Research and Practice, Proceedings of the 10th International Conference on Computer Aided Architectural Design Futures*, edited by Mao-Lin Chiu, Jin-Yeu Tsou, Thomas Kvan, Mitsuo Morozumi, and Tay-Sheng Jeng, Kluwer Academic Publishers, Dordrecht, 249-258.
12. Champion, E. (2003). Applying Game Design Theory to Virtual Heritage Environments. In S. Spencer (Ed.). *Graphite2003, Proceedings of the First international conference on Computer graphics and interactive techniques in Australasia and South East Asia, Melbourne, Australia*, (pp. 273-274). 11-14 February, ISBN, 1-58113-578-5.
 13. Champion, E., & Dave, B. (2002). Where is this place? *ACADIA2002* 24-27 October 2002, Association For Computer Aided Design In Architecture- Pomona USA, October 2002, 87-97. ISBN, 1-880250-11-X.
 14. Champion, E. (2002). Cultural Engagement in Virtual Heritage Environments with Inbuilt Interactive Evaluation Mechanisms. In F. Gouveia (Ed.). *Proceedings of the Fifth Annual International Workshop PRESENCE 2002*, Porto Portugal, October 2002, 117-128.
 15. Champion, E. (2001). Travels Through the imagination: Future Visions of VR and Related Technologies. In *YVR2001, Young VR 2001 Forum*, KAIST, Daejeon, 18-19 December 2001, Presentation 12. Also available on CD.

13.3 Conference Papers Only

1. Champion, E. (2003). Floating on the Primal Sea: Utzon and Dissolution in Nordic Architecture, *First Utzon Symposium*, 28-30 August 2003, Aalborg.
2. Champion, E. (2002), Cognitive Mapping in Virtual Environments. *ASPIRE 2002*, Castlemaine, Victoria, July 2002.
3. Champion, E. (2002). Creating Virtual Environments for Archaeological Reconstructions. *Land and Sea: Common Ground and Contemporary Issues for Australasian Archaeology*. Townsville, November 2002. (Conference proceedings only).
4. Champion, E. (2002). Evoking Cultural Presence in Virtual Heritage Environments. *CAAUK 2002*, (poster), Belfast, May 2002.